ALLEN, MELONY HOLYFIELD, Ph.D. Thoughtfully Adaptive Teaching in Fourth-Grade Science Instruction. (2011)
Directed by Drs. Catherine E. Matthews and Bev Faircloth. 205 pp.

The purpose of this study was to examine teachers' thoughtfully adaptive teaching. Teachers' instructional adaptations made while teaching and during planning when implementing the Full Option Science System "Magnetism and Electricity" unit were identified. This study highlighted teachers' vision-linked adaptations. A multiple case mixed-methods research design was used to document the types and frequencies of teachers' instructional adaptations and the associated rationales for these adaptations. Teachers' vision-linked adaptations were also described and the nature of the relationship between teachers' vision-linked adaptations and students' science learning was investigated. Students' science learning was defined by gain scores on the unit pre- and posttest that accompanied the *FOSS* curriculum materials.

A goal of this study was to expand and broaden the understanding of thoughtfully adaptive teaching by including teachers' adaptations made during planning for and while teaching science; describing teachers' vision-linked adaptations; and exploring the nature of the relationship between teachers' vision-linked adaptations and students' science learning. This research study built upon existing thoughtfully adaptive teaching studies (Duffy et al., 2006; Parsons et al., 2010). Data consisted of responses to interviews, lesson observations and students' scores from unit pre- and posttests. The findings suggest that teachers' who draw on their vision of teaching to make instructional adaptations may positively impact students' learning.

THOUGHTFULLY ADAPTIVE TEACHING IN FOURTH-GRADE

SCIENCE INSTRUCTION

by

Melony Holyfield Allen

A Dissertation Submitted to
the Faculty of The Graduate School at
The University of North Carolina at Greensboro
in Partial Fulfillment
of the Requirements for the Degree
Doctor of Philosophy

Greensboro
2011

Approved by

____
Committee Co-Chair

____
Committee Co-Chair

In memory of Jerry Wayne Holyfield, Jr.

Sorrow makes us all children again, destroys all differences of intellect. The wisest know nothing. ~Ralph Waldo Emerson

APPROVAL PAGE

This dissertation has been approved by the following committee of the Faculty of The Graduate School at The University of North Carolina at Greensboro.

Committee Co-Chairs __________________________________

____

Committee Members __________________________________

____

____

Date of Acceptance by Committee

____

Date of Final Oral Examination

ACKNOWLEDGMENTS

Many people have played a part in this journey, turning it into an adventure.

Thank you Roney, Wesley, and Cameron for always knowing when I should take a break and be a “mama.” I needed this reality check many times and I appreciate you all for the patience you had while I finished this “paper.” I love the three of you more than love!

Thank you Mama and Daddy. You two are my biggest supporters and made sure to “keep it real” and put things into perspective when it was needed the most. I love you both so much!

Thank you Becky and Rich. Becky, you played when I needed to play, let me work when I needed to work and now, I can’t wait to see what we will get into! I love you! Rich, thank you for sharing Becky with me! I can’t imagine my life without you two in it.

Thank you Committee Members. Dr. Matthews, I want to be like you when I grow up! Dr. Faircloth, your open door and support has meant the world to me! Dr. Duffy, thank you for welcoming me into the literacy world and encouraging me to pursue thoughtfully adaptive teaching! Dr. Harrington, thank you for all of our spontaneous talks and believing in me!

Thank you to the teachers in this study. Your willingness to open your hearts, classrooms, and teaching made this work possible. By far, one of the best things in this journey was being in your classrooms and “getting inside your heads.”

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Page

CHAPTER I

INTRODUCTION

Teachers work with increasingly diverse student populations that vary in their abilities, interests, linguistic backgrounds, and previous experiences. To best meet all students' needs, teachers must use their professional knowledge to make instructional decisions. Expert teachers use their professional knowledge in flexible ways to make instructional decisions (Berliner, 2001; Bromme, 1982; Randi & Corno, 2000). To succeed in such complex environments, teachers must be adaptive (Helmke &Weinert, 1997). While teaching, an adaptive teacher adjusts the course of the lesson accordingly when she notices students' difficulties. Similarly, during planning an adaptive teacher anticipates students' diverse paths in learning and plans accordingly (Vogt & Rogalla, 2009).

Two books recently published by the National Academy of Education (Darling-Hammond & Bransford, 2005; Snow, Griffin, & Burns, 2005) presented "adaptive expertise" as the pinnacle of teaching. Adaptive expertise, they explained, strikes a balance between innovation and efficiency. Teachers must be efficient in that they routinize research-based best practices. However, teachers must also be innovative, so that they can deal with the unpredictable nature of classrooms. Likewise, Lin, Schwartz, and Hatano (2005) presented the theory of "adaptive metacognition." They argued that teaching is highly unpredictable: "Teachers . . . confront highly variable situations from student to student and class to class. One solution does not fit all, and teachers need metacognitive approaches that support adaptation and not just improved efficiency for completing recurrent cognitive tasks" (p. 245).

Research studying expert teachers has identified adaptive teaching as a characteristic of effective teaching. Summarizing Taylor and Pearson's (2002) CIERA project on effective schools and accomplished teachers, Duffy and Hoffman (2002) stated, "Instruction is a complex orchestration of techniques and materials that teachers creatively adapt from one instructional situation to another. Glossing over this complexity is misleading" (p. 385).

Adaptive teaching is more than just cognitive, it is also affective because one must be disposed to being thoughtfully adaptive in response to complex and unanticipated problems that arise (Meloth & Deering, 1999). Further, Fairbanks, et al. (2010) provide the theoretical argument that "teacher educators must develop teachers' self-knowledge and sense of agency in addition to developing standard forms of professional knowledge" (p. 161).

Similarly, Hammerness (2008), stated "Successful teachers cannot simply have an intuitive or personal understanding of a particular content, principle, or theory . . . Vision brings together teachers' passions, their hopes, cares, and dreams with their knowledge about how and what children should be learning" (pp. 5, 24). Linking visioning and effectiveness, Duffy (2002) indicated that teachers must "be psychologically strong enough to use professional knowledge in creatively resourceful ways" (p. 332) and that teachers who have a vision are often able to “adjust, modify, and invent; they do not [just] emulate” (p. 333).

If effective teachers are adaptive and possess visions, then perhaps teachers’ vision-linked adaptations are a significant contributing factor to students’ learning. Therefore, this study specifically investigated four fourth grade science teachers’ vision-linked adaptations they made when implementing the *Full Option Science System (FOSS)* “Magnetism and Electricity” unit and students’ learning as evidenced by scores on a unit posttest provided with the *FOSS* curriculum materials. The instructional goals of the curriculum unit are to foster students’ scientific literacy and to support teachers’ instructional efficiency. Further details about the unit will be provided later in this chapter.

This study is situated within the context of a larger research agenda associated with others who have examined “thoughtfully adaptive teaching” (TAT) (Duffy et al., 2006; 2008; Parsons, Davis, Scales, Williams, & Kear, 2010). Thoughtfully adaptive teaching is defined as a teacher action that (a) is non-routine, proactive, thoughtful, and improvisational; (b) includes a change in professional knowledge or practice; and (c) is done to meet the needs of a student or an instructional situation (Duffy et al., 2008). The goals of the larger research agenda are to understand the nature of teachers’ adaptations in a variety of teaching contexts and the nature of the relationship between TAT and student outcomes. A series of dissertations (Davis, 2009; Kear, 2009; Parsons, 2008; Scales, 2009, Howard, 2011; Vaughn, 2011; and now, mine) have been completed at our university under the guidance of Dr. Gerald Duffy and colleagues (Faircloth, Harrington, Matthews, and Miller). Collectively, these studies have provided a foundation of methodological procedures in which to examine TAT and a typology that may be used to code teachers' adaptations and the rationales that they provide for the adaptations they make (see Tables 1 and 2). The previous TAT studies were conducted in literacy classrooms with teachers who typically were required to follow certain programs of instruction, and only examined teachers' adaptations made while teaching (while teaching is often referred to by previous TAT researchers as 'on the fly' teaching) literacy. From these studies, we know that elementary teachers make adaptations while teaching literacy to meet students' instructional needs.

Table 1

Thoughtfully Adaptive Teaching Adaptation Codes

Thoughtfully Adaptive Teaching Adaptations
I – Modifies the lesson objective
II – Changes means by which objectives are met
III – Invents examples, analogy or metaphor
IV – Inserts a mini-lesson
V – Suggests a different perspective to students
VI – Omits/inserts Activity
VII – Changes planned order of instruction

Table 2

Thoughtfully Adaptive Teaching Rationale Codes

Thoughtfully Adaptive Teaching Rationales
A – Objectives not met
B – Challenge/Elaborate
C – To teach a specific strategy of skill
D – To help students make connections
E – Uses knowledge of students or classroom dynamics to alter instruction
F – Checking students understanding
G – Anticipation of upcoming difficulty
H – To manage behavior
I – To manage time
J – To promote student engagement

However, we still do not know if teachers make adaptations during planning, what the nature of teachers' adaptations in other curricular areas is like, what the adaptations of teachers who are not required to follow certain programs of instruction might look like, and we still do not have evidence to establish a link between teachers' adaptations and student learning outcomes. It has been suggested that more thoughtful adaptations may be associated with high potential teachers who possess deep professional knowledge (Parsons, 2008). However, previous TAT studies have not clearly defined "professional knowledge" even though teachers' use of professional knowledge is embedded in the definition of TAT and used to rate the thoughtfulness of teachers' adaptations and rationales. Therefore, for the purposes of this study, professional knowledge is defined as a type of cold cognition that teachers possess related to pedagogy and content. Davis (2009) suggested that teachers' adaptations may draw on knowledge of self, which represents their personal visions. For the purposes of this study, vision-linked adaptations represented a type of hot cognition in which teachers draw on their knowledge of self. Perhaps, then adaptations made by teachers who posses well-developed professional knowledge (a type of cold cognition related to pedagogy and content) and make vision-linked adaptations (a type of hot cognition related to their vision) may influence students' learning in significant ways.

Consequently, the purpose of this study was to expand our understanding of TAT and therefore this study varied from the previous studies in that teachers' adaptations were examined while teaching **and during planning** for **science** and within a teaching context in which teachers were **not bound** to follow certain programs of instruction. Also examined were teachers' adaptations that were **linked to their visions of teaching** and the **nature of the relationship between teachers' vision-linked adaptations and their students' science learning**. This research provided a systematic analysis of four fourth grade teachers' adaptations made while teaching and during planning throughout their implementation of the *Full Option Science System (FOSS)* "Magnetism and Electricity" unit.

Importance of the Study

This study builds on the limitations of previous TAT studies. Previous TAT studies have been conducted only in literacy in a school system that required teachers to adhere to particular programs of instruction; examined only adaptations while teaching; were concerned mostly with teachers' use of professional knowledge, a major component that signals an adaptation and has been used to rate the thoughtfulness of teachers' adaptations and rationales; and has reported findings using frequency counts. TAT researchers have not yet addressed the question of whether or not TAT matters in terms of students' learning. While previous TAT research has contributed tremendously in helping us to begin to understand TAT, it is time to expand and deepen our understanding of TAT.

This study crossed the border of literacy to expand into science classrooms with teachers who were not bound to adhere to a particular program of instruction, and thus were perhaps more free to make instructional decisions of their own accord. This study adds depth to our knowledge of TAT by documenting the adaptations that science teachers made while teaching and during planning; exploring another dimension of teachers' knowledge (knowledge of self, in the form of vision-linked adaptations) and describing teachers' vision-linked adaptations and exploring the nature of the relationship between vision-linked adaptations and students' science learning.

This study also has very practical purposes that may be used by teacher educators. These contributions will be further discussed in Chapter V.

Building on the important work of previous TAT researchers, this study aimed to add to the existing knowledge of TAT and was guided by the following questions.

Research Questions

The questions that guided this study were:

1. What is the nature of four fourth grade science teachers' adaptations while teaching and during planning when implementing the *FOSS* "Magnetism and Electricity" unit?
2. What is the nature of the four fourth grade teachers' vision-linked adaptations?
3. What is the nature of the relationship between four fourth grade teachers' vision-linked adaptations and students' science learning?

Rationale for the Study

For over a decade scholars have suggested and provided some evidence that adaptive teaching signals an effective teacher (e.g. Brandsford, Darling-Hammond, LePage, 2005; Randi & Corno, 2000; Williams & Baumann, 2008). The most recent work pursued by the researchers who have completed TAT dissertations (Davis, 2009; Kear, 2009; Parsons, 2008; Scales, 2009) examined teachers' adaptations for "thoughtfulness." Thoughtfulness of adaptations was rated on a continuum based on teachers' use of professional knowledge. For example, to distinguish among considerably thoughtful, thoughtful, and minimally thoughtful, adaptations and rationales had to meet the following criteria: (a) the teacher showed exemplary or creative use of professional knowledge or practice and (b) the adaptation or rationale was clearly associated with a larger goal the teacher held for literacy growth (i.e., the adaptation or rationale is motivated by a desire to develop a deep or broad understanding or a conceptual or attitudinal goal). To be rated as thoughtful, the adaptation or rationale (a) had to be tied to the specific lesson or to a larger goal the teacher wanted to develop and (b) could not meet any of the criteria for minimally thoughtful. The following criteria qualified teachers' adaptations and rationales as minimally thoughtful: (a) the adaptation or rationale required minimal thought, (b) the teacher's use of professional knowledge or practice was fragmented, unclear, or incorrect, or (c) the adaptation or rationale did not contribute to the development of either a larger goal or a specific lesson objective.

This focus on professional knowledge was certainly important yet it was not clearly defined. However, the general agreement among the TAT team of researchers is that teachers' "professional knowledge" includes knowledge of content, pedagogy and the like. In other words, teachers' professional knowledge has to do more with their rational cognitive knowledge, or a type of cold cognition, rather than teachers' affective, motivational and dispositional factors, or types of hot cognition.

Others (Duffy, 2002; Fairbanks et al., 2010; Hammerness, 2008; Meloth & Deering, 1999) have suggested that effective teachers must also possess a vision, a type of hot cognition, in addition to their professional knowledge. However, no research to date has examined vision-linked adaptations as a measure of effectiveness in terms of students' learning. There is a pressing need for this research that examines teachers' vision-linked adaptations and the nature of the relationship between their vision-linked adaptations and students' science learning.

Research Design

This research implemented an interpretative multiple case study, mixed-methods approach that investigated teachers' adaptations while teaching and during planning throughout the implementation of the *Full Option Science System (FOSS)* "Magnetism and Electricity" unit, the nature of their vision-linked adaptations and the nature of the relationship between their vision-linked adaptations and students' science learning. Drawing on the work of Creswell (2003), Creswell and Plano Clark (2007), and Tashakkori and Teddlie (1998, 2003), Denscombe (2008) wrote:

> the defining characteristics of the mixed methods approach involve its use of: quantitative and qualitative methods within the same research project, a research design that clearly specifies the sequencing and priority that is given to the quantitative and qualitative elements of data collection and analysis, an explicit account of the manner in which the quantitative and qualitative aspects of the research relate to each other, with heightened emphasis on the manner in which triangulation is used. (p. 272)

Specifically, this study was a sequential exploratory design that was characterized by an initial phase of qualitative data collection and analysis, followed by a phase of quantitative data collection and analysis, with the priority given to the qualitative aspects of the study (Creswell, 2003). The qualitative data collection and analysis of this study examined teachers' visions (articulated during the pre-study interview), and how (captured in lesson observations) and why (based on teachers' rationales offered in pre-lesson and post-lesson interviews) teachers made adaptations and vision-linked adaptations while teaching and during planning. The quantitative data collection and analysis of this research examined the frequency of teachers' adaptations and vision-linked adaptations and target students' unit pre- and posttest scores. Both data collection and data analyses will be described in greater detail in Chapter III.

Limitations of the Study

A limitation to this study is that I examined only four fourth grade teachers. Although studying all four fourth grade teachers within one school setting, during every lesson of the science unit, likely allowed me to capture their adaptations and vision-linked adaptations it also reduced the likelihood of the results being generalizable to a greater population because I was in one school with teachers all in the same grade, teaching the same material.

Additionally, it should be noted that teachers in this study were extremely collaborative, often discussing their lessons with one another over lunch or during planning periods. Some of the adaptations and vision-linked adaptations captured may have been made as a result of another colleague's decision or based on the reported experiences of the lesson as it was shared between participants. To address this issue of teachers collaborating and thus influencing each other's decisions about when and how to make instructional adaptations, I observed all four teachers on the same days and conducted the post-lesson interviews immediately after the lesson. When possible, I conducted the next day's pre-lesson interview following the post-lesson interview before participants were able to communicate. Further, each participant was supervising a full-time student teacher. Their supervision responsibilities may have impacted the adaptations they made in order to maintain a consistent teaching schedule for the student teacher. Finally, engaging in post-lesson interviews in which participants reflected on the lesson may have impacted participants' subsequent adaptations as a result of something that was discussed during the post-lesson interview.

Terms Defined

TAT in this study, like all the other studies examining TAT, was defined as a teacher action that (a) is non-routine, proactive, thoughtful, and improvisational; (b) includes a change in professional knowledge or practice; and (c) is done to meet the needs of a student or an instructional situation (Duffy et al., 2008). Professional knowledge was defined as a type of cold cognition that teachers possessed related to pedagogy and content.

An adaptation for this study was defined as a form of executive control in which teachers modify their professional knowledge and/or practices during either planning or teaching in order to meet the needs of particular students or particular instructional situations.

An adaptation during planning was a teacher report of a change during the pre-lesson interview that is related to one of the following: (a) a modification in district or school requirements, (b) a modification of materials, (c) a modification from how the lesson has been previously taught, or (d) a modification of instructional strategies. To be considered a planned adaptation and therefore, included in the data analysis the adaptation was carried out while teaching.

An adaptation while teaching was an adaptation during the lesson when the teacher made a non-routine proactive decision that required thought and was invented on the spot in order to make instruction suitable for the goal the teacher was pursuing. It was

(a) non-routine, proactive, thoughtful and invented, (b) included a change in the professional knowledge or the professional practices the teacher was using, and (c) performed by anticipating the needs of students or instructional situations.

The reason a teacher provided in a pre-lesson or post lesson interview for an adaptation made during planning or while teaching was a rationale.

Science instruction was defined as the teacher's instruction using the *FOSS* unit "Magnetism and Electricity" as the basic guide that she followed. A description of this is found at the conclusion of this section.

A student's science learning was a student's score defined by the gain score from the unit pre- and posttest that was part of the *FOSS* curriculum materials. Gain score percentages were determined by dividing by the actual gain (the difference between the score on the unit posttest and the score on the unit pretest) by the potential gain (100% - the unit pretest score). Further, a student's science knowledge of magnetism and electricity was ranked as adequate if the student scored above 70% or above and not adequate if the student scored below 70%.

The teacher's vision was defined as a teacher's self-reported statement of her image of teaching during a pre-study interview that contained the following content: (a) why she became a teacher, (b) what she wants to accomplish as a teacher, (c) what she wants her students to learn and become, (d) how she attempts to enact her vision, and (e) what barriers she perceives that inhibit her from enacting her vision.

A teacher's vision-linked adaptation represented a type of hot cognition in which she drew on her knowledge of self. A vision-linked adaptation was an adaptation that met the criteria above for an adaptation made during planning or while teaching and in which the teacher's rationale provided evidence that her intent was to promote an aspect(s) of the content of her vision that was identified in the pre-study interview.

An obstacle was defined as what the teacher perceived and reported as a barrier that prevents her from pursuing a certain course of action that she otherwise would pursue.

Description of the *FOSS* "Magnetism and Electricity" Unit

FOSS curriculum materials were developed at the Lawrence Hall of Science, University of California at Berkeley and nationally field-tested. *FOSS* materials provide teachers with curriculum materials designed to provide "meaningful science education for all students in diverse American classrooms and to prepare them for life in the 21st century" (Full Option Science System, 2009, para. 1). The units aim to promote students' appreciation for the scientific enterprise, and aim to have students learn important scientific concepts and develop the ability to think critically by engaging in investigations and analyses of their own inquiries. Each *FOSS* unit contains a teacher guide, equipment necessary for implementation, teacher preparation videos and science stories that can be used as supplemental material when implementing units. *FOSS* units are correlated to a number of state and regional standards, as well as to the *National Science Education Standards* (NSES).

Specifically, the "Magnetism and Electricity" unit focuses on students' development of observation and descriptive skills as well as providing evidence-based explanations. There are five investigations in the unit that focus on physical science concepts. Table 3 illustrates the alignment of the "Magnetism and Electricity" unit with the North Carolina Standard Course of Study (NCSCOS).

Table 3

FOSS "Magnetism and Electricity" Unit Aligned with NCSCOS

NCSCOS Competency Goal 3: The learner will make observations and conduct investigations to build an understanding of magnetism and electricity	
NCSCOS Objectives	**Aligned Component of Unit**
3.01: Observe and investigate the pull of magnets on all materials made of iron and the pushes or pulls on other magnets	Investigation One: The Force Science Stories: "Magnus Gets Stuck," "Magnificent Magnetic Models," "How Magnets Interact," "Make a Compass"
3.02: Describe and demonstrate how magnetism can be used to generate electricity	Science Stories: "From Rags to Science: A Story of Michael Faraday," "Magnets and Electricity in Your Life"
3.03: Design and test an electrical circuit as a closed pathway including an energy source, energy conductor, and energy receiver.	Investigation Two: Making Connections
3.04: Explain how magnetism is related to electricity	Investigation Four: Current Attractions Science Stories: "From Rags to Science: A Story of Michael Faraday," "How Electromagnets Stopped a War," "Magnets and Electricity in Your Life"
3.05: Describe and explain the parts of a light bulb	Investigation Two: Making Connections Science Stories: "Magnets and Electricity in Your Life"
3.06: Describe and identify materials that are conductors and nonconductors of electricity	Investigation One: The Force
3.07: Observe and investigate that parallel and series circuits have different characteristics	Investigation Three: Advanced Connections
3.08: Observe and investigate the ability of electric circuits to produce light, heat, sound, and magnetic effect	Investigation One: the Force Investigation Two: Making Connections Investigation Three: Advanced Connections Investigation Four: Current Attractions Science Stories: "Magnets and Electricity in Your Life"
3.09: Recognize lightning as an electrical discharge and show proper safety behavior when lightning occur	Science Stories, "Making Static" and "A Fictional Interview with Benjamin Franklin"

(adapted from http://www.delta-education.com/science/foss/correlations/NorthCarolina.pdf)

Summary and Organization of Dissertation

The purpose of this study was to examine four fourth grade science teachers' instructional adaptations made while teaching and during planning throughout the implementation of the *FOSS* "Magnetism and Electricity" unit. I was particularly concerned with teachers' adaptations that were linked to their visions of teaching. As such, another purpose of this study was to explore the nature of the relationship between teachers' vision-linked adaptations and their students' science learning defined by target students' scores on the *FOSS* "Magnetism and Electricity" unit pre- and posttest. This mixed-method, multiple case study approach allowed me to systematically examine teachers' adaptations made while teaching and during planning, in which I focused on teachers' vision-linked adaptations and target students' science learning.

This introductory chapter provided a rationale for this study and an overview of the research design. The remainder of this dissertation is organized into four chapters. Chapter II provides a review of the literature. Chapter III describes the methodology for this study and Chapter IV presents the findings and a discussion of the findings. Chapter V provides suggestions for future areas of research as well as discusses implications of the findings for teacher educators. Additionally, limitations of the applications of the findings from this study are noted.

CHAPTER II

REVIEW OF THE LITERATURE

The purpose of this study was to examine teachers' instructional adaptations while teaching and during planning when implementing the *Full Option Science System (FOSS)* "Magnetism and Electricity" unit. I also explored teachers' vision-linked adaptations and the nature of the relationship between teachers' vision-linked adaptations and their students' science learning. This chapter begins with a review of the literature in which adaptive teaching has been discussed as a component of effective teaching. Next, previous thoughtfully adaptive teaching (TAT) research is described. As part of the description of previous TAT research, I highlight Parsons' (2008) TAT study and explain how his finding that openness of tasks was related to teachers' adaptations relates to my examination of inquiry-based science instruction. As a result, I describe the literature related to the open nature of inquiry-based science instruction. Then, I discuss how my study addresses questions that Davis (2009) raised related to teachers' adaptations based on their visions of teaching and teachers' adaptations made during planning. The literature related to teacher visioning and decision making during planning is reviewed. A subset of the literature on teachers' decision making during planning is the literature related to teachers' use of curriculum materials. This review of literature ends with a description of the literature related to teachers' use of curriculum materials. As I review each category of literature presented in this chapter, I embed discussion about how my study was informed by the existing literature.

Adaptive Teaching as an Indicator of Effective Teaching

The literature indicates that a component of effective teaching is associated with being an adaptive teacher; some researchers refer to adaptive teaching as “adaptive expertise” (Darling-Hammond & Bransford, 2005; Snow, Griffin, & Burns, 2005). Teachers who demonstrate adaptive expertise flexibly apply their professional knowledge about teaching to meets students’ instructional needs. Lin, Schwartz, and Hatano (2005) describe the process of “adaptive metacognition” as a “change to oneself and to one’s environment in response to a wide range of classroom social and instructional variability” (p. 245). Thoughtfully adaptive teaching is both adaptive expertise and adaptive metacognition. Teachers must be metacognitive in responding to teachable moments (Duffy et al, 2008).

Much of the research that has informed our understanding of adaptive teaching has examined expert teachers, those with in-depth professional knowledge. For example, Westerman (1991) found that while teaching, expert teachers deviated from their lesson plans to attend to students’ contributions to lessons whereas novice teachers maintained the course of the lesson as it was written in the plan. Similarly, O’ Conner and Fish (1998) found a significant difference between novice and expert teachers “adaptability and responsiveness to students” (p. 475 as cited in Berliner, 2001). Schemp, et al (1998) found that expert teachers who were teaching in an area that they were most knowledgeable of drew on a “plan of independence” from their lesson plan to respond to students' learning needs. Adaptive teaching is also an embedded component in learner-centered classroom practices, which has been positively correlated with adolescents' engagement and achievement (Meece, Herman, & McCombs, 2003).

The theory and research associated with the above notions of adaptive teaching has informed the research that has been conducted under the thoughtfully adaptive teaching (TAT) umbrella (discussed in Chapter 1). The literature indicates that effective teachers adapt while teaching in ways that may positively impact students' learning. While previous TAT studies have not examined students' learning, it seems imperative that we search for empirical evidence that does indeed determine whether or not instructional adaptations seem to effect student learning. In the following section, a review of previous~~ly~~ TAT research is provided and then specific attention is given to Parsons' (2008) and Davis' (2009) studies.

Previous Thoughtfully Adaptive Teaching Research

Overview

As previously mentioned in Chapter I, earlier TAT studies focused on teachers' use of professional knowledge (a type of cold cognition related to pedagogy and content). Our understandings of TAT are derived from a compilation of individual studies that have been conducted with this focus on teachers' professional knowledge in similar contexts with replicated methodological procedures, which has allowed for comparisons and verification of findings while also deepening our understanding about how to best capture teachers' adaptations while teaching and their rationales for making adaptations (Duffy, et al., 2006, 2008; Parsons et al., 2010). Using grounded theory, the researchers who conducted these early studies of TAT validated robust coding systems for adaptations and the associated rationales that teachers made, providing future TAT researchers with a common typology to categorize teachers' adaptations and rationales (see Tables 1 and 2 in Chapter I). It is important to note though that all of these earlier studies examined teachers' adaptations while teaching literacy (adaptations during planning or adaptations while teaching other subjects were not studied). Additionally, these studies were conducted with teachers who worked in a school system that promoted fidelity of program implementation, or compliancy to particular programs of instruction and did not investigate the impact of TAT on students' learning.

Early Studies

Duffy et al. (2006) began the exploration of TAT with a study that questioned whether or not literacy teachers' adaptations could be identified. Researchers examined six in-service and thirteen pre-service teachers and indeed were able to identify literacy teachers' adaptations. The results indicated very little variation in the types of adaptations between in-service and pre-service teachers. To further understand the nature of adaptations that literacy teachers made while teaching, Duffy and colleagues conducted additional studies.

Four studies in 2007 conducted by the TAT research team examined six pre-service and two in-service teachers' TAT in literacy. This collection of studies also interviewed students to see if students understood the intent of the adaptations that teachers made. From this set of studies, the seven adaptation codes (see Table 1 in Chapter I), the ten rationale codes (See Table 2 in Chapter I) and a thoughtfulness rubric (previously described in Chapter I) used to rate teachers' adaptations and rationales were all developed.

Second Phase of Studies

Across another set of studies summarized by Parsons et al. (2010), TAT researchers examined 24 literacy teachers across 154 lessons. Researchers aimed to understand how, why and to what extent teachers' adaptations were thoughtful. They used the coding systems for teachers' adaptations and rationales from previous studies described above and the thoughtfulness rubric as mentioned above and previously described (in Chapter I). Findings from these studies indicated that across 24 literacy teachers and 154 lessons that 353 adaptations were made. The most commonly occurring adaptation was teachers inventing an example, analogy or metaphor. The most frequently occurring rationale that teachers provided was that objectives were not met. The majority of teachers' adaptations in these studies were rated minimally thoughtful. It is important to note that all of these studies took place within a school system where there were requirements to adhere to certain programs of literacy instruction. Time after time, TAT researchers have speculated that this may be a factor in the types of and frequencies of adaptations that they have found.

To date, TAT research has been conducted across approximately 50 literacy classrooms in a school system in which scripted curriculum materials were common. Further, these studies have rated the thoughtfulness of both the teachers' adaptations and rationales made during instruction. The overall results of this research indicate that literacy teachers adapt their instruction while teaching ('on the fly') and do so with intentions to meet students' instructional needs.

In this section of the literature review, I have provided an overview of previous TAT research and chronicled the important work that has been done in order to move the larger TAT research agenda forward. In the following paragraphs, I describe two studies in particular that inform much of the work in this study. First, I discuss Parsons' (2008) study, which has implications related to the openness of inquiry in science instruction. After I describe these implications I review the literature related to inquiry-based science instruction and openness. Then, I discuss Davis' (2009) study and address the implications of her study related to teachers' visions and adaptations made during the planning phase of instruction. Next, I describe the literature related to teacher visioning and teacher decision-making during planning.

Parsons' research. Of particular importance to this study, were the studies conducted by Parsons (2008) and Davis (2009). Parsons' study drew on research that ". . . has demonstrated that open literacy tasks—assignments that are authentic, collaborative, challenging, student-directed, and sustained—are beneficial for students' motivation and learning" (p. 1) and examined the relationship between tasks and adaptations. Specifically, he measured the openness of the tasks teachers implemented, the adaptations they made, the rationales they offered for adapting, and the relationships among these phenomena. The findings indicated that open literacy tasks require that teachers adapt their instruction more often than closed literacy tasks: "when teachers implement open literacy tasks, they tend to adapt their instruction more often, in more thoughtful ways, and for more thoughtful reasons than when they use closed literacy tasks" (p. 116, Parsons, 2008).

Given the findings of Parsons' study, it stands to reason that the open nature of inquiry-based science instruction might also be characterized by more numerous adaptations made while teaching. This study examined TAT in the context of inquiry-based science instruction. Therefore, in the following paragraphs I explain the continuum of inquiry as it relates to the openness of task.

Inquiry-based science instruction and openness. Inquiry in science can surface in various forms and can be described based upon the degree to which students experience opportunities to ask and answer their own questions (Windschitl, 2003). Aligning with the continuum that Windschitl (2003) suggested, there are four forms of inquiry: (a) confirmation, (b) structured inquiry, (c) guided inquiry, and (d) open inquiry. As instruction moves along this continuum, students' become more intellectually challenged. Windschitl further points out that as teachers' instruction moves towards open inquiry, it becomes more pedagogically complex. For example, it is more intellectually challenging for students to have to design and implement procedures to answer questions that are posed by the teacher (guided inquiry) than it is to have those procedures provided for them (structured inquiry). Likewise, the pedagogical approach for guided inquiry is more complex than structured inquiry.

Based on this continuum and using Windschitl's language, the lowest level of inquiry consists of confirmation experiences where teachers provide students with the procedures to verify known scientific principles. This is considered the level at which students are less intellectually challenged and the least pedagogically complex for teachers. The next level is noted as structured inquiry. At this level, teachers provide questions for students to answer and provide the procedures for students to follow in order to answer the questions. The intellectual ability of students is more challenged in this form of inquiry than it is in confirmation experiences. Pedagogically, a structured inquiry form is also more complex than the confirmation experience form. The third level, guided inquiry, is yet even more intellectually challenging for students as well as pedagogically more complex for teachers. Finally, the most intellectually challenging form of inquiry for students is open inquiry. In this kind of inquiry, students develop their own questions and design their own ways to answer those questions. Open inquiry is the most pedagogically complex for teachers. The teacher may provide the subject matter but otherwise students have full control of developing questions and methods for answering those questions. Given Parsons' (2008) findings and the above information related to inquiry in science, we might expect that science teachers will adapt more frequently as their science teaching approaches open inquiry and it may be especially important to study TAT is science.

Davis' research. Based on categories of knowledge defined by Grossman (1995), Davis (2009) examined the knowledge teachers used to make adaptations during instruction. Grossman's categories include teachers' knowledge of content; learners and learning; general pedagogy; curriculum; and self.

Davis' findings indicated a narrow use of knowledge (in regards to Grossman's knowledge categories that were represented in teachers' adaptations while teaching) in which teachers drew mostly from their knowledge of learners and learning and less frequently from their knowledge of content or pedagogy and rarely from their knowledge of curriculum, context and self. Furthermore, most of their adaptations were rated minimally thoughtful.

Davis suggested that scripted curriculum materials might limit teachers in their decision-making and thus instructional adaptations. Davis indicated that future TAT studies should examine the extent to which teachers draw from their knowledge of self. Highlighting, Grossman's categories in which knowledge of self is described as teachers' conception of personal values, dispositions, educational philosophy, and goals for students and teaching, knowledge of self can then be thought of as knowledge of one's vision for teaching. Davis also pointed out that teachers' adaptations made during the planning phase of teaching may be where teachers make more robust adaptations.

Accordingly, this study examined teachers' vision-linked adaptations and teachers' adaptations made during planning, in addition to examining general adaptations (not vision-linked) made while teaching. Below, the literature related to teacher visioning is first reviewed followed by a review of the literature on teachers' decision making during planning.

Teacher visioning. Teacher educators generally agree that teachers need a vision for teaching to guide their practice (Shulman & Shulman, 2004; Hammerness et al., 2005). The literature linked to teacher visioning also indicates that teachers' visions contain a moral component, a kind of knowledge that is different from professional knowledge. For example, Duffy (2002) specifically states that visioning is "a matter of the heart and the spirit, of personal morality and passion" (p. 3). As pointed out by McNay and Graham (2007), the literature that regards teaching as a calling (Hansen, 1995; Huebner, 1987), a moral endeavor (Huebner, 1996), emotional (Zembylas, 2003), or spiritual (Palmer, 2008) also suggests that ". . . good teachers possess a vision for education (Duffy, 2002; Hammerness, 2001) or a sense of mission (Korthagen, 2004)" (p. 225).

For Hammerness (2006), a vision for teaching is about a teacher's hopes for what could be within the classroom or in the larger community. Hammerness further points out that for some teachers, their visions may be a source of inspiration. Yet for others, a vision may serve as a measuring stick in which to measure their teaching effectiveness. When visions of teaching are used this way, as a measuring stick to gauge teaching effectiveness, Hammerness warns that teachers may experience conflict or tension between what they hope to accomplish and the reality of their teaching context.

Clearly, there is general agreement that teachers need a vision but this is hardly enough to assist teachers in making thoughtful decisions. That is, professional knowledge must be combined with a teacher's vision.

This idea of merging teachers' visions and professional knowledge is also supported in the literature. For example, scholars have suggested that a strong intellectual component, or professional knowledge needs to be coupled with teachers' visions so that teachers may draw on both when making instructional decisions (Shulman & Shulman, 2004; Darling-Hammond & Baratz-Snowden, 2005; Duffy, 2002; Palmer, 1998). Feiman-Nemser (2001) argues that effective teacher preparation programs produce beginning teachers with a ". . . compelling vision of good teaching and a beginning repertoire of approaches to curriculum, instruction and assessment consistent with that vision" (p. 1029). Similarly, Shulman and Shulman (2004) propose that "teachers with a vision may be more reflective and purposeful, evaluating their instruction based on the needs of their students" (p. 240) and that clarity of teachers' vision helps them to do this.

Previous TAT studies have been focused only on teachers' use of professional knowledge. This current study maintained that focus (by definition an adaptation indicates that the teacher is drawing on professional knowledge) but also examined teachers' vision-linked adaptations, which signaled that the teacher merged her vision and professional knowledge.

Scholars indicate that a teacher's vision needs to be integrated with their professional knowledge and that the clarity of a teacher's vision may assist the teacher with making instructional decisions. However, the empirical evidence to support such conjectures is limited to only a few studies. These are described below.

Studies examining vision. Hammerness (2000, 2003, 2004, 2005, 2006) has written extensively on teacher visioning Hammerness indicates that a vision involves "maintaining the delicate balance between constantly shifting demands of subject matter and students' needs; and dealing with the uneasy tension between their ideals and their current practice" (Hammerness, 2006, p. 5).

Hammerness's work echoes the importance of the clarity of teachers' visions that was previously pointed out. She suggested that a clear vision can assist teachers in reflecting and imagining how to move from current practice to their ideal practice. At the same time, however, clarity of one's vision can also bring about discouragement if the vision is left unaccomplished. Hammerness's position is that a teacher's vision should be clear *and* compatible with the organization if visions are to be enacted. She also indicates that when a teacher's vision is met with policy or circumstances that are in contention with the vision, that teaching efficacy can be threatened.

McElhone et al. (2009) incorporated Hammerness' (2003) definition of vision as "images of ideal classroom practice" (p. 43). They found that the context in which teachers worked, their visions and teachers' professional knowledge all played a significant role in teachers' practice. For example, in their study a new teacher who began her teaching career in a supportive context, possessed a coherent and clear vision and a solid knowledge of literacy instruction, was able to continue to develop into an stronger, or more effective literacy teacher. Her teaching substantially improved over the course of her first year of teaching. Another new teacher who also possessed a coherent and clear vision for teaching and a solid knowledge of literacy instruction who began her teaching career in a challenging and unsupportive environment was able to maintain strong teaching practices from her preservice-teaching experiences, despite the lack of support.

Others have also examined the intersection of teachers' visions, teaching context and teaching practice. For example, McLoughlin's (1999) study examined the intersection of a preservice science teacher's philosophy, her field experiences and practice. The findings of this study indicated that when the preservice teacher's philosophy of reform-oriented approaches to science instruction, such as inquiry, was challenged by the boundaries of accepted practices in her field experience (with science being taught in traditional lecture format) that she began to question her own goals. Although this finding contradicts what was found in McElhone's study, both McElhone's and McLoughlin's studies indicate that the teaching context may provide opportunities to confirm professional images of teaching (visions) or those images may conflict with the context of the classroom or school. Further, both studies confirm that visions of teaching intersect with practice and context.

If effective teachers merge their professional knowledge with their visions, then surely the clarity of teachers' visions and the context in which they teach are critical variables in how they do so. Consequently, my study was concerned with identifying and describing teachers' vision-linked adaptations (which signal teachers' use of both professional knowledge and vision). Further, this study was conducted in a teaching context that allowed for teachers to make instructional decisions that they deemed necessary.

Previous TAT research examined only teachers' adaptations made while teaching and as Davis (2009) suggested, this study expanded the scope of TAT to include adaptations made during planning. Therefore, the literature on teacher decision-making during planning is reviewed in the following paragraphs. While the literature related to teachers' decision making during planning has a long history, the more recent literature of teachers' use of curriculum materials is a subset of this literature. Therefore, I first discuss the literature related to teachers' decision making during planning and then I review the current literature related to teachers' use of curriculum materials

Teacher decision making during planning. The teacher decision-making literature has well-established that during planning teachers: (a) draw on aspects of the classroom environment to make decisions, (b) center their planning decisions around activities, (c) make decisions about the content to teach, and (d) decide how to situate or provide an instructional context for teaching (Clark & Yinger, 1979; Marland, 1977; Shavelson, Cadwell, & Izu, 1977). Through the late 1970s into the 80s, research that focused on the relationship between teachers' thoughts and actions in the classroom linked teacher planning to classroom instruction (Clark & Elmore, 1981). Shavelson and Borko (1979), for example, offered the term preactive teaching to refer to teachers' planning, preparing materials, and considering previous student work to inform planning that occurs before instruction. Olson (1981) used this concept of preactive teaching to describe the process of science teachers, in particular, as accessing varied instructional materials as well as their past experiences when planning instruction. That is when teachers are making decisions during planning they are considering many aspects that revolve around making decisions about what to teach, how to teach, and the purpose for teaching a particular concept or activity. As teachers engage in these considerations, it is clear then that extensive thought occurs during planning and thus planning is a logical place to study teachers' adaptations.

As mentioned above, studies of teacher planning indicate that teachers' interaction with curriculum materials is part of the process of planning for instruction. In my study, teachers used curriculum materials as the primary guide for instruction but were not required to adhere to the curriculum materials. Next, I describe the literature related to teachers' use of curriculum materials.

Teachers' use of curriculum materials. Recent research indicates that curriculum materials, depending on the content and organization of the materials, can act as a support or barrier during teachers' planning and enactment (Brown, 2009). Brown (2009) citing three significant features of curriculum materials as representations of (a) concepts, (b) tasks, and (c) physical objects used for lessons, specifies that curriculum materials with well-designed activities and high-quality resources dealing with content and pedagogy are likely to help teachers interact with materials in productive ways that support student learning. The *FOSS* curriculum materials used in this study were considered to be of such quality that they could be considered supports for teachers' instruction (see Chapter I for a description). Further, teachers were free to adapt the curriculum materials as they deemed necessary.

According to research there are also characteristics of teachers that may either promote or act as barriers in regards to teachers' use of curriculum materials. One characteristic includes teachers' knowledge and beliefs about the subject matter, teaching, and learning (Brown, 2009; Forbes & Davis, 2008; Kauffman, 2002; Olson, 1981; Squire et al., 2003). Another characteristic is teachers' pedagogical design capacity (Brown, 2009). Research informing these two characteristics of teachers is described in the following paragraphs.

Remillard (1999) examined two elementary teachers' uses of the same reform oriented mathematics textbook in the process of enacting curriculum. She aimed to understand how curriculum materials might foster changes in teaching by analyzing the relationships between teachers, textbooks, and the enacted curriculum. Remillard (1999) stated, referring to one of the participants, “As her ideas about teaching and learning mathematics shifted, so did her teaching and use of the text; both became more adventurous and responsive to students” (p. 321). For this participant then, it appears that using curriculum materials that aligned with her beliefs that she was also able to become more adaptive.

The second participant “. . . moved from a position of doubt about her mathematical and pedagogical choices to one of confidence” (p. 321). Remillard indicated that the second participant shifted her reliance on the text because her beliefs about mathematical learning drove her to find the necessary resources that were not present in the textbook.

Remillard’s study demonstrated how teachers’ knowledge and beliefs about subject matter teaching and learning influence their interactions with curriculum materials. We can assume then that the ways that teachers in this dissertation study interacted with the curriculum materials were in part ways that represented the merging of their professional knowledge and visions for teaching. Further, because all of the teachers in this study had been trained to use the materials and had implemented the curriculum materials in previous year(s) we can also assume that they were knowledgeable of and had past experience on which to base their adaptations. Ms. Rose, a second year teacher in this study had implemented the curriculum materials during her first year of teaching while Ms. Landers, Ms. Lawson and Ms. Winn each had implemented the curriculum materials since 2004, the year their school system adopted the *Teacher and Scientists Collaborating Initiative.*

Another characteristic of teachers that influences the teacher-curriculum materials relationship is teachers' pedagogical design capacity. Pedagogical design capacity refers to a teacher's "ability to perceive and mobilize existing resources in order to craft instructional contexts" (Brown, 2009, p. 24). That is, when applying pedagogical design capacity, effective teachers are able to negotiate the supports and barriers of curricular features while also considering their own understandings, instructional goals, and classroom needs. In other words, teachers who possess a capacity for pedagogical design adapt curriculum materials as they notice the need to do so.

While teachers' pedagogical design capacity plays a major role in their use of curriculum materials, contextual factors are equally important in how teachers design and enact curriculum materials (Sherin & Drake, 2009; Squire et al., 2003; Remillard, 2000). For example, Kauffman (2002) found that for beginning teachers the "most prominent contextual factors are institutional norms and expectations" (p. 14). It was further pointed out that the contextual norms and expectations communicate the degree to which schools and districts endorse the use of the curriculum materials. One major conclusion from this study was that "from the beginning teacher's perspective, the ideal situation would be to have curriculum materials that align with individual beliefs and that are endorsed by the school and district" (p. 23).

Clearly*,* teachers interact with curriculum materials and ultimately make the decisions that result as the planned and enacted curriculum. However, it is not as simple as this. There are multiple factors to consider that influence the decisions that teachers make that are related to teachers' knowledge and beliefs about the subject matter, teaching, and learning and teachers' pedagogical design capacity. Further, contextual factors also play a role in the planned and enacted curriculum.

I conducted this research in a context where the curriculum materials were not necessarily prescribed. Teachers had the option of adhering to the materials as written or adapting them in ways they deemed necessary, but they were required to use the materials provided. Granting teachers the privilege of making instructional adaptations reduced the likelihood that teachers were negatively influenced by the context in which they taught and therefore provided a more accurate picture of how teachers' visions might influence the adaptations they made to the curriculum materials during planning. Further, this study considered teachers' characteristics through their articulated visions and the role teachers' visions played in how they used the curriculum materials while planning and during teaching.

Summary of the Review of Literature

In this review I have provided a review of the literature that informs this study and includes thoughtfully adaptive teaching as an indicator of effective teaching as well as previous thoughtfully adaptive teaching research. In doing so, I highlighted two specific studies (Parsons, 2008 and Davis, 2009) that especially informed this dissertation. As such, I also reviewed the literature related to the open nature of inquiry, teacher visioning, teacher decision making during planning and teachers' use of curriculum materials. Embedded in the review of the literature I pointed out how this study was informed by such research. In the following chapter, Chapter III, I will discuss the methodological considerations of this study.

CHAPTER III

METHODOLOGY

This purpose of this study was to expand understandings of thoughtfully adaptive teaching (TAT) by investigating four fourth grade science teachers' instructional adaptations made while teaching and during planning throughout the implementation of the *Full Option Science System (FOSS)* "Magnetism and Electricity" unit. Teachers' vision-linked adaptations and the nature of the relationship between teachers' vision-linked adaptations and students' science learning were examined. Specifically, this study aimed to answer the following questions: (a) What is the nature of four fourth grade science teachers' adaptations while teaching and during planning when implementing the *FOSS* "Magnetism and Electricity" unit, (b) What is the nature of the four fourth grade teachers' vision-linked adaptations, and (c) What is the nature of the relationship between four fourth grade teachers' vision-linked adaptations and students' science learning? To best answer these questions, I used a sequential exploratory mixed-methods approach to data collection and analysis (Creswell, 2003). This study examined multiple cases (four fourth grade teachers) at the same elementary school (my research site) and a purposeful sample of each teacher's students' ($N = 23$) science learning. Teachers were each asked to select two students each who were high achievers, average achievers and low achievers and these became the target students for this study and I examined only their science learning as defined in this study.

Case studies are best used for answering "how" and "why" research questions (Yin, 2003). Examining how and why teachers made vision-linked adaptations allowed me to describe the nature of teachers' vision-linked adaptations. Using a case study approach also allowed evidence from a variety of sources (interviews, lesson observations, students' posttest scores) to be triangulated in an iterative reflexive data analysis process (Srivastava & Hopwood, 2009).

The main units of analysis in this study were teachers' visions (articulated during pre-study interviews), adaptations (captured during pre-lesson interviews, that is while planning or while talking about planning and while teaching), and the rationales offered for the adaptations they made (gathered during pre- and post-lesson interviews). Another unit of analysis was students' science learning (as measured by the *FOSS* "Magnetism and Electricity" unit posttest).

This study was a multiple-case study because each teacher was the subject of an individual case study, while the study as a whole covered an entire grade level of teachers at one school. The multiple-case study was used for two reasons. First, findings that independently surface from two or more cases allow the study as a whole to be more robust (Yin, 2003). Second, the characteristics of multiple cases are likely to differ to some extent. For this study, each teacher had taught fourth grade for a different number of years. Additionally, the teachers had different science backgrounds and two of the four teachers possessed Master's degrees. Given these variances, if common conclusions are generated, then the findings can be expanded towards more generalizability (Yin, 2003).

In this study, the cases provide insight into the vision-linked adaptations that teachers made during planning and while teaching the *FOSS* unit “Magnetism and Electricity” and the relationship between the frequency of teachers’ vision-linked adaptations and students’ science learning. The *FOSS* materials were chosen as the unit of implementation because all four teachers were trained in the unit implementation through their school system’s *Teacher and Scientists Collaborating Initiative* that began in 2004. Teachers were required by the school system to spend an entire day in professional development at the Center for Inquiry Based Learning (CIBL) before they were given the unit to implement with their students. After the required staff development, teachers had access to ongoing support, with options of calling or emailing staff developers at CIBL. All of the teachers had prior experience implementing the unit at the school where this study was conducted. Additionally, the *FOSS* “Magnetism and Electricity” unit aligned nicely with the North Carolina Standard Course of Study.

This study began with individual pre-study interviews with each teacher. Before and after every lesson, I conducted a pre- and post-lesson interview with each teacher. All 13 of the lessons implemented in the unit were observed. All four teachers chose six students who represented the learning continuum of general education students in their classes (two high-achieving students, two average-achieving students and two low-achieving students). However, one student moved and posttest results were not available, leaving a total of 23 target student participants (with respect to the data analysis).

Qualitative data were collected to enable the researcher to understand each teacher’s vision and each teacher’s adaptations and rationales for the adaptations they made. The adaptations that teachers made during planning were coded with pre-established codes (see Table 4). The adaptations made while teaching and rationales for the adaptations made while teaching and during planning were coded with the typology provided by previous TAT researchers (see Tables 1 and 2 in Chapter I). Teachers' adaptations made during planning and while teaching and the associated rationales were coded and counted so that the nature of teachers' adaptations could be reported.

Table 4

Adaptations Made during Planning Codes

Adaptation Made During Planning
1 – Modification of district or school requirement
2 – Modification of materials
3 – Modification in how the lesson has been done in the past
4 – Modification in the instructional strategies used

Each teacher's pre-study interview was examined, individually, for unique features of each teacher's vision. Each teacher's adaptations and rationales were compared to the unique features of her vision to identify vision-linked adaptations so that teachers' vision-linked adaptations could be described and counted. Quantitative data were collected in the form of unit pre- and posttest scores to examine students' science learning. These data were analyzed to assist with understanding the nature of the relationship between teachers' vision-linked adaptations and students' science learning. The types of qualitative and quantitative data are described in more detail in sub-sections of this chapter.

Research Site

The following section describes the school in which this study took place. An overview of the demographics of teachers and students who participated in the study is provided. Further, my professional relationship and interactions with those associated with the research site is explained.

Western Elementary (pseudonym), a public Title I, K-5 Elementary School, is located in rural North Carolina. At the time of this study, 486 students attended Western. Of the student population that Western served, 49% qualified for free or reduced lunch, 6% were identified as academically gifted, 15% were exceptional students, and 20% of students were English language learners.

All of the teachers were considered highly qualified under *No Child Left Behind* legislation. That is, all 25 classroom teachers at Western were certified to teach at the grade level in which they taught. Eleven percent of the teachers at the school held Master's Degrees. The range of years of teaching experience among the entire faculty was almost equally distributed between 0-3 years (39%), 4-10 years (31%) and +10 years (31%).

Also, at the time of this study, Western was engaged in a professional development school (PDS) partnership with the University of North Carolina at Greensboro (UNCG). Before forming a PDS partnership, several meetings were held to establish that both teachers and administrators would be supportive of science teaching. As part of this PDS partnership, 19 pre-service teachers who were members of UNCG's Environmental Education/Science Team, spent, on average, ten hours per week in 19 of the 25 teachers' classrooms and were full-time student teaching at the time of this study. The teachers at Western acted as On-Site Teacher Educators (OSTEs) for UNCG.

As a university supervisor of interns and student teachers placed at Western, I recognized that I could be viewed as an outsider since I am associated with UNCG. In order to reduce this threat to validity, I established a positive and professional relationship with teachers. In doing so, I attended grade level meetings, assisted with coordinating "curriculum night," shared instructional resources as teachers requested or showed interest, supervised student interns, and assisted with judging the science fair. My efforts were to support Western and to work collaboratively with school staff.

Participants

Teacher Participants

The fourth grade teachers in this study were white females who were in their mid 20s to early 30s. The four teachers in this study had various levels of teaching experience (see Table 5). They also varied in their teacher preparation experiences, degrees possessed and science backgrounds. These aspects for each teacher participant are discussed below.

Ms. Landers (all names are pseudonyms) was in her eighth year of teaching. All of her teaching experience had been at Western. She had taught third, fourth, and fifth grades. This was her fifth year of teaching fourth grade. She completed her teacher education program at Elon College, earning a Bachelor's degree in Elementary Education with a minor in Spanish. She was a NC Teaching Fellow who received a full scholarship to Elon College in exchange for committing to teach at least four years in NC. Ms.

Landers served as Ms. Rose's (a second year teacher in this study) mentor and was appointed this duty by the principal at Western.

Table 5

Descriptions of Teachers' Background

Teacher	Number of years of In-service Teaching Experience			Pre-service Teacher Education Experience			Science Background Beyond Requirements
	Total	4th Grade	Western Elementary	Institution	Degree(s)	Grades Certified to Teach	
Landers	8	5	8	Elon College (NC Teaching Fellow)	Bachelor's	K-6	–*AP Biology
Lawson	4	4	4	St. Thomas Aquinas	Bachelor's and Master's	K-6	None
Rose	2	2	2	UNCG (NC Teaching Fellow)	Bachelor's	K-6	– *AP Environmental Science –Environmental Education/ Science Team Member in Pre-service
Winn	5	5	5	Virginia Polytechnic Institute and State University	Bachelor's and Master's	K-6	– Science student teaching placement in 4th grade (full semester)

*High School Advanced Placement Courses

Ms. Lawson was in her fourth year of teaching. All of her teaching experience had been at Western. She earned a Bachelor's degree in Elementary Education from St. Thomas Aquinas College and completed her Master's of Education degree with a concentration in Children's Literature from Pennsylvania State University. The year this study was conducted, Ms. Lawson was chosen by her colleagues as “Teacher of the Year” for Western.

Ms. Rose was in her second year of teaching. This was also her second year of teaching fourth grade at Western. As a member of a two-year science cohort team that was co-led by me, Ms. Rose completed her teacher preparation program at UNCG and earned a Bachelor’s degree in Elementary Education with a concentration in English. She was a North Carolina Teaching Fellow who, like Ms. Landers received a full scholarship to a NC college (in this case, UNCG) in exchange for committing to teach at least four years in NC.

Ms. Winn was in her fifth year of teaching. All of her teaching experience has been at Western. She attended Virginia Polytechnic Institute and State University for both undergraduate and graduate school. Her Bachelor’s degree was in Human Development with a concentration in Early Childhood Education. Her Master’s degree was in Elementary Curriculum and Instruction. Her student teaching experience was a component of her graduate work, and was completed in a fourth grade science classroom.

It should be noted that I have a significant professional and personal relationship with Ms. Rose as I was her fifth grade teacher, during my second year of teaching. We both have also lived in and grew up in the same county that this study took place. During Ms. Rose’s teacher education program, as indicated previously, I co-lead her team. Since Ms. Rose completed her teacher education program, we have maintained significant contact beyond her acting as an OSTE for UNCG. Ms. Rose and I often discuss professional and personal matters through face to face meetings, phone calls and emails.

I chose teacher participants as a purposive sample (Maxwell, 2005). All four teachers were intentionally selected based on a principal recommendation and their willingness to participate and provide open feedback about their instruction.

Before any data were collected, I explained the background and purpose of this study to the four teachers in a group meeting. All four teachers were informed of their rights as participants and of the benefits and risks associated with participating in this study. Teachers indicated agreement to participate with their signatures on consent forms before any data were collected.

Student Participants

The four teacher participants selected student participants who they believed to be representative of the general education learning continuum in their classroom. That is, each teacher was asked to select two low-achieving students, two-average achieving students and two high-achieving students to participate in this study who were not identified as special needs students. One high-achieving student in Ms. Lawson's class moved during the course of the study and therefore only 23 target students' unit posttest results were used in the analysis. Table 6 represents the 23 target students' achievement levels as identified by the teacher and the target students' gender.

Parents of students were informed of the purpose of this study and the benefits and risks associated with their student's participation. Parental permission was indicated by a parent's signature on a consent form. Additionally, student participants' signatures were obtained on assent forms to indicate students' willingness to participate in this study.

Table 6

Target Students' Achievement Levels as Identified by the Teacher and Gender

Students' Achievement Level	Total	Female	Male
Low	8	3	5
Average	8	4	4
High	7	5	2
Total	23	12	11

Design of the Study

The goal of this study was to expand the understanding of adaptive teaching. To accomplish this goal, I examined the nature of four fourth grade science teachers' adaptations while teaching and during planning when implementing the *FOSS* "Magnetism and Electricity" unit. I was especially interested in teachers' vision-linked adaptations and the nature of the relationship between teachers' vision-linked adaptations and students' science learning as measured by the *FOSS* "Magnetism and Electricity" unit posttest. Given the goal of this study, I examined the types of and frequencies of adaptations teachers made while teaching. I also examined the types of and frequencies of adaptations made during planning. The types of and frequencies of teachers' rationales for the adaptations they made while teaching and during planning were examined in regards to the types of TAT rationales. With my interest in teachers' vision-linked adaptations, I examined teachers' articulated visions to determine features of individual teacher's vision and compared the adaptations teachers made while teaching and during planning to the features of the individual teacher's vision. Teachers' types of and frequency of vision-linked adaptations and the rationales teachers' provided for the vision-linked adaptations they made while teaching and during planning, were examined in regards to the types of TAT adaptations and rationales. The frequencies of and types of vision-linked adaptations and target students' unit posttest scores and gain scores were examined to best understand the nature of the relationship between teachers' vision-linked adaptations and students' science learning. Gain score percentages were determined by dividing by the actual gain (the difference between the score on the unit posttest and the score on the unit pretest) by the potential gain (100% - the unit pretest score). Given the complexity of this research, an interpretative multiple case study, mixed-methods approach was taken in this study. A mixed methods approached permitted qualitative and quantitative data collection and analyses in this interpretative multiple case study. Mixed methods also allowed me to determine the nature of four fourth grade science teachers' adaptations while teaching and during planning when implementing the *FOSS* "Magnetism and Electricity" unit and to determine and describe the nature of teachers' vision-linked adaptations as well as the nature of the relationship between teachers' vision-linked adaptations and students' science learning.

Qualitative and quantitative data were collected in this study. See Figure 1 for a visual of the strategies used. First, teachers articulated their visions during a pre-study interview. These interviews served as a source of data to determine the features of teachers' visions, which were used to identify vision-linked adaptations. Teachers' adaptations while planning were collected through pre-lesson interviews and had to be enacted in the lesson observation to be considered as part of the data analysis.

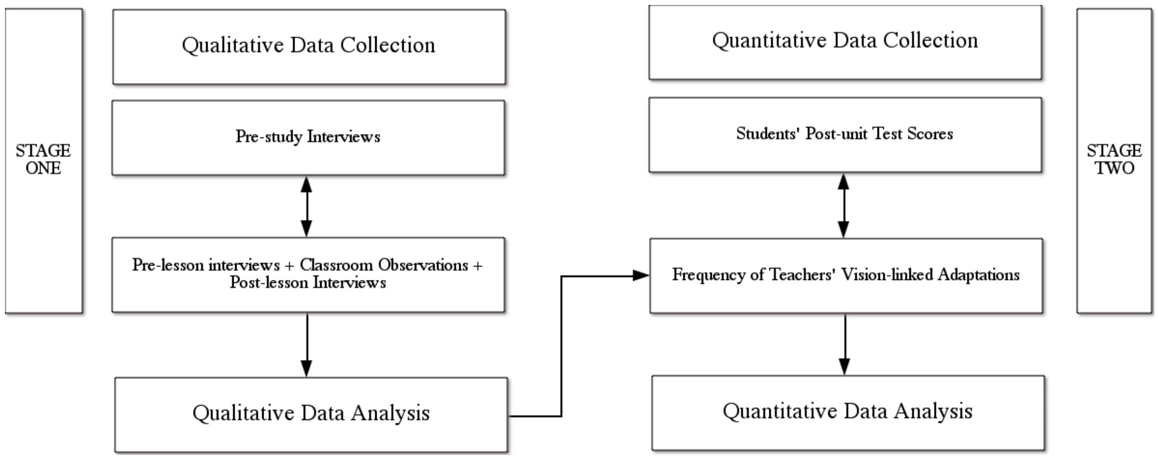


Figure 1. ***Data Collection and Analysis Strategies***

Teachers' adaptations while teaching were gathered in lesson observations. During post-lesson interviews, all of the adaptations were confirmed by the teacher and the rationales provided for the adaptations made while teaching were noted. After all the adaptations and rationales were analyzed for type using TAT adaptation and rationale codes, all of the adaptations were analyzed to determine if they were vision-linked adaptations. Teachers' adaptations and rationales were corroborated with the features that were determined from analysis of teachers' pre-study interviews. After all adaptations were analyzed to determine if they were vision-linked, frequency counts of teachers' vision-linked adaptations were made and comparisons of teachers' vision-linked adaptations and rationales were made. This analysis was compared to the target students' unit posttest scores and target students' gain scores. Further a Pearson's correlation coefficient was used to determine the strength of the relationship between the frequency of teachers' vision-linked adaptations and target students' science learning as measured by the FOSS "Magnetism and Electricity" unit posttest.

Many researchers point out the benefits of approaching data collection and analysis through mixed methods. For example, Morse (1991) commented that using complementary data on the same topic can allow for a better understanding of the research problem. In this study, complementary quantitative data were used to answer all three research questions: (a) What is the nature of four fourth grade teachers' adaptations while teaching and during planning when implementing the *FOSS* "Magnetism and Electricity" unit, (b) What is the nature of the four fourth grade teachers' vision-linked adaptations, and (c) What is the nature of the relationship between four fourth grade teachers' vision-linked adaptations and students' science learning? In this way, a more thorough understanding of the nature of teachers' adaptations made while teaching and during planning and vision-linked adaptations was gleaned. Furthermore, using complementary quantitative data allowed for a way to begin to understand the nature of the relationship between teachers' vision-linked adaptations and students' science learning. Using mixed methods also allowed for qualitative data to be transformed into quantitative data so that the two could be mixed during the analysis stage for comparisons (Creswell & Plano Clark, 2007). During the analysis stage teachers' adaptation and rationale codes were transformed into frequency counts so that patterns could be determined about the types of the adaptations made while teaching and during planning. Further, teachers' vision-linked adaptations were transformed into frequency counts using TAT adaptation and rationale codes and by the features that were represented in their vision-linked adaptations. This allowed for an examination of existing patterns in light of target students' gain scores.

Conceptual Framework

This study is grounded in a theoretical framework that defines effective teaching as teaching practiced by adaptive teachers. Effective teachers are adaptive teachers who draw on their professional knowledge (content and pedagogical knowledge) to make instructional decisions (Bransford, Darling-Hammond, & LePage, 2005); effective teachers are metacognitive (Lin et al., 2005); and effective teachers draw on their visions of teaching to make instructional decisions (Duffy, 2002).

Effective teaching is adaptive teaching (Allington & Johnson, 2002; Randi & Corno, 2000). Allington and Johnston (2002) studied effective fourth-grade teachers and concluded that, "although they plan their instruction well, they also take advantage of teachable moments by providing many apt mini-lessons in response to student needs throughout the school day" (p. xiii). Williams and Baumann (2008) found that "excellent teachers demonstrated instructional adaptability, or an ability to adjust their instructional practices to meet individual student needs" (p. 367).

Effective teachers are metacognitve. Lin et al. (2005) emphasizing the highly variable situations that teachers encounter from day to day and moment to moment, point out that to move beyond just being efficient, teachers must also be metacognitive. That is, teachers must consider the situations they encounter and think about the best ways to adapt their instruction.

Previous TAT research has been based on the notions that effective teachers are adaptive and metacognitive and that when the need arises teachers draw upon their professional knowledge (content and pedagogical knowledge) to make decisions about what to do. An adaptation by definition is a form of executive control in which teachers modify their professional information and/or practices during either planning or teaching in order to meet the needs of particular students or particular instructional situations. Metacognition has long been understood to inform students' self-regulation of learning through a process of "thinking about one's thinking" and the regulation of that thinking (Flavell, 1979, 1987). By analogy, then, teacher metacognition is "thinking about one's thinking" and the regulation of that thinking in pursuit of student learning (Duffy et al., 2009; Zohar, 2006).

Effective teaching is also associated with the teachers who possess a vision of teaching. Duffy (2002) speculated that teachers with visions may be positioned to use their professional knowledge in creative ways. Hammerness (2008) pointed out that successful teachers' have visions, which bring together their knowledge and hopes for students. Most recently Fairbanks et al. (2010), referring to self-knowledge, suggested that thoughtful teachers possess a vision and the propensity to enact it. Hence, the conceptual framework for this study included teachers' visions as a kind of knowledge that teachers may draw upon when making an instructional adaptation.

Given this conceptual framework, this study assumed that (a) teachers actions or adaptations during planning and while teaching result from their professional knowledge (content and pedagogical) and metacognition and (b) teachers' adaptations may be linked to their vision. A visual representation of the conceptual framework used in this study is shown in Figure 2.

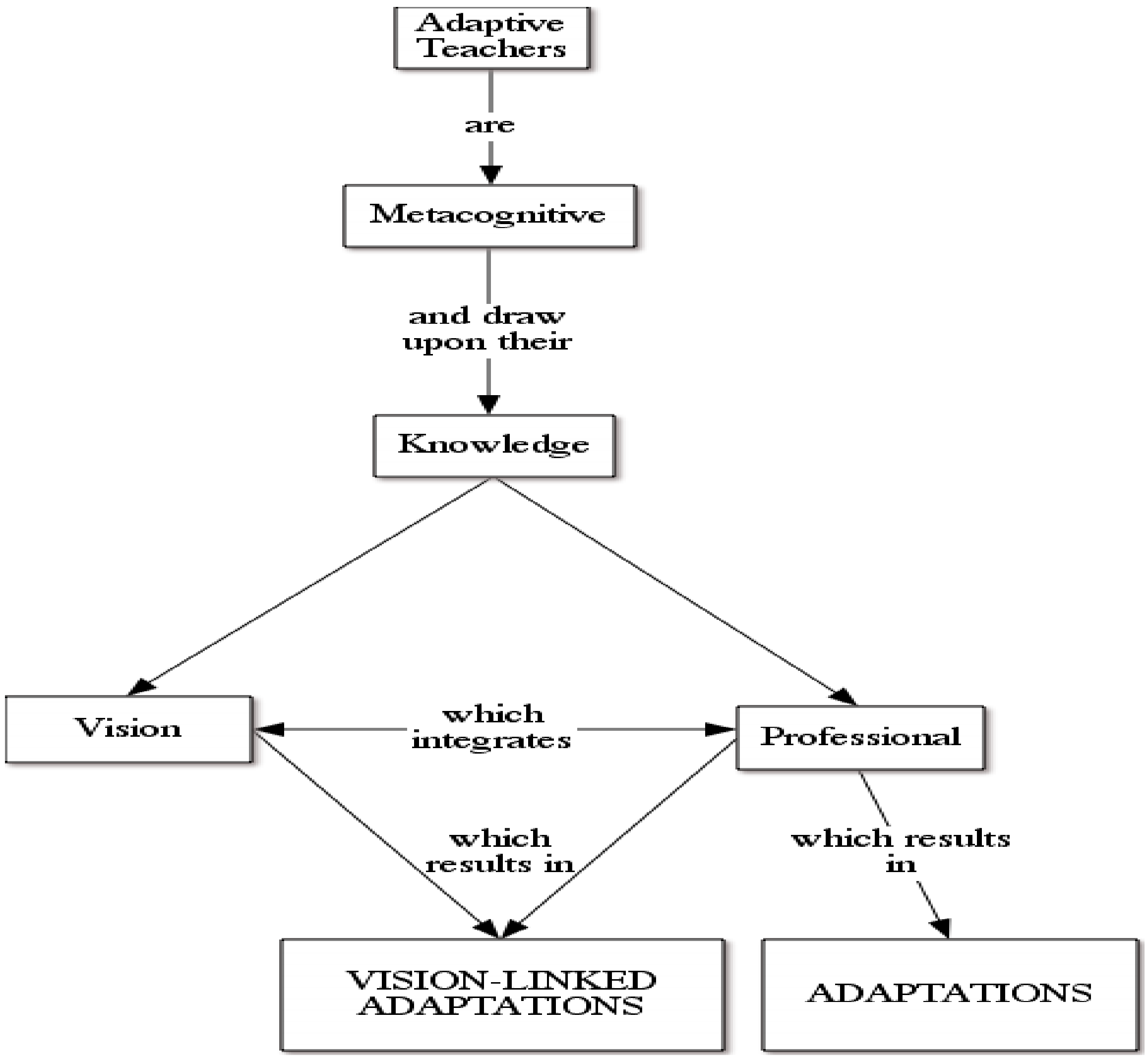


Figure 2. ***Conceptual Framework***

Research Procedures

This research used both qualitative data and quantitative data. The qualitative data sources included interviews and lesson observations. Quantitative data included the transformation of the qualitative data into frequency counts and target students' unit pre- and posttest scores. Data collection procedures were influenced by the design of this research. Multiple sources of data were used to ensure trustworthiness. Table 7 provides a crosswalk between the research questions and the sources of data used to gather the necessary information. After Table 7, a description of each data source is provided.

Table 7

Crosswalk of Research Questions and Data Sources

	Data Sources				
	Interviews				
Research Question	**Pre-study**	**Pre-lesson**	**Post-lesson**	**Lesson Observations**	**Target Students' Unit Pre- and Post-test Scores**
What is the nature of four fourth grade science teachers' adaptations while teaching and during planning when implementing the *FOSS* "Magnetism and Electricity" unit?	X	X	X	X	
What is the nature of the four fourth grade teachers' vision-linked adaptations?	X	X	X	X	
What is the nature of the relationship between four fourth grade teachers' vision-linked adaptations and students' science learning?	X	X	X	X	X

Pre-Study Interviews

Data collection began with pre-study interviews (See Appendix A for protocol). The purpose of the pre-study interviews was to gain an understanding of teachers' visions so that features of teachers' visions could be determined. In order to best understand teachers' visions, questions were asked that prompted teachers to respond in ways that allowed insight about their reasons for becoming teachers, their hopes of what they want to accomplish as teachers, their aims of what they want students to learn and become, their approaches to science instruction, their attempts to enact their vision, and their encounters of barriers as they attempt to enact their vision. All pre-study interviews were audiotaped and transcribed. From the pre-study interviews, the features of teachers' vision were determined. The features of teachers' visions served as a measure which could be used to identify teachers' vision-linked adaptations.

Pre-lesson Interviews

To gather data related to the adaptations each teacher made during planning and the rationales associated with those adaptations, a pre-lesson interview was conducted prior to every lesson. For each participant, three pre-lesson interviews were conducted through the popular web-based social networking community, Facebook. After three pre-lesson interviews on Facebook, the teacher participants indicated that they preferred to have face-to-face pre-lesson interviews during school hours. Therefore, the last ten of the thirteen pre-lesson interviews were conducted face-to-face with each teacher individually. These ten pre-lesson interviews were audiotaped and transcribed for analysis.

An interview protocol, which consisted of three main questions, was used during all of the pre-lesson interviews (see Appendix B). The protocol allowed me to probe for teachers' goals, objectives and instructional strategies. Additionally, the protocol allowed me to identify the teachers' adaptations made during planning by eliciting responses to questions about changes the teacher was making in terms of the following: (a) modification of district or school requirements; (b) modification in what the materials suggested the teacher to do; (c) modification in how the teacher had conducted this kind of lesson in the past and (d) modification in the instructional strategies. Finally, if the teacher indicated one or more of these changes, then I elicited her rationale for the adaptation.

Lesson Observations

Lesson observations enabled me to verify that an adaptation made during planning was carried out and allowed me to identify adaptations made while teaching. I observed each teacher's science instruction 13 times for the duration of the unit implementation. The 13 lessons were taught over a span of five weeks during the 40-minute instructional block designated for science. While observing, I scripted as much as possible the events that occurred in each lesson. I noted what the teacher said and what she did and when appropriate, what students were doing and saying. When it appeared that the teacher deviated from the lesson plan, I made a note of that on the observation protocol (see Appendix C).

I used an observation protocol developed by previous TAT researchers (Duffy, et al., 2008) to record field notes. The protocol had two sections. One section had space to record the name of the teacher being observed, the date of the observation, and the time of the observation. The second section had a space for recording field notes and adaptations the teachers made. After each lesson I conducted a post-lesson interview with the teacher.

Post-lesson Interviews

On the same day of lesson observations, I conducted a semi-structured post-lesson interview (see Appendix D). All post-lesson interviews were audiotaped and transcribed for analysis. During the post-lesson interview, I asked the teacher about all of the adaptations that I noted. I prompted the teacher with "When I saw you ______________________, was that an adaptation, something you had not planned to do?" In order to be considered in the analysis, the teacher had to verify that it was an adaptation that she had not planned to do and thus was considered as an adaptation made while teaching. When she confirmed it, I asked for her rationale. I always concluded the interview by asking "Were there adaptations made during the lesson that we have not talked about?" This provided the opportunity for the teacher to identify adaptations that I may have failed to capture. The semi-structured interview protocol allowed me to probe as needed and encouraged elaborated responses so that a better understanding of the teachers' rationales for making adaptations could be established (Creswell, 2005).

The above sources provided the necessary data for analysis so that the nature of teachers' adaptations in regards to previous TAT research could be identified and so that teachers' vision-linked adaptations could be identified and therefore described. During this phase of the research, the qualitative data were transformed into frequency counts. That is, frequency counts of teachers' adaptation and rationale types that they made while teaching and during planning as well as teachers' vision-linked adaptations were determined. The nature of teachers' vision-linked adaptations served as another source of data so that the frequencies could be compared to students' gain scores to examine the nature of the relationship between teachers' vision-linked adaptations and students' science learning. The data sources used in the second phase of this study are described below.

Students' Unit Pre- and Posttests

Before beginning any instruction associated with the FOSS "Magnetism and Electricity" unit, all four teachers administered the unit pretest that was provided in the curriculum materials. After implementing the entire unit of instruction all four teachers re-administered the unit pretest as a unit posttest. The unit pre and posttest were the same (see Appendix E).

The test contained 15 items. Some of the items were open-ended (9), some items were multiple choice items (5), and one item was a fill in the blank but did not provide a word bank from which to choose. The first item asked students to determine if objects were magnetic and if objects conducted electricity. This item assessed students' understanding of two concepts: (a) that magnetic items contain steel or iron, and (b) that metals conduct electricity. The second item required students to draw wires from the negative and positive points of a battery to the correct contact points of a bulb in order to make it light. The next item provided a picture of three bar magnets with like poles pushed together and students were to choose the correct multiple-choice response about what would happen when the force holding the bar magnets together was released. The fourth item provided a scenario that provided part of the process to construct an electromagnet and asked that students determine the next steps. Students were required to provide a short-answer written response. In the fifth item, another scenario was provided in which students had to explain why magnets snap together when they get close to each other. Item six required students to draw arrows from wires connected to a motor and battery to indicate the direction of the flow of electricity. The seventh item provided a picture of a parallel circuit with three light bulbs and required students to write about what would happen if the middle light bulb went out and to provide an explanation for this event. For item eight, a scenario was provided about making an electromagnet. Students had to determine which rivets were appropriate to use (copper, steel, iron) and explain why these rivets were appropriate. Item nine provided a list of materials and required students to determine and describe two ways to make a temporary magnet. Item ten required students to describe how to make an electromagnet stronger. For item number eleven, students were required to identify the changes of electric energy from a bulb and a motor. Students had to explain the force of magnetism through cardboard for item twelve. Items thirteen, fourteen and fifteen were multiple choice items that were related to students' understanding of the flow of electricity, repelling magnets and that magnets are attracted to iron objects. A copy of the unit pre- and posttest is provided in Appendix E.

The *FOSS* curriculum materials included a scoring guide for the pretest/posttest. The pretest and posttest were identical, distinguished only by the time (pre-teaching or post-teaching) that they were administered (see Appendix F). The scoring guide consisted of model student responses. Target students' unit pre and posttest responses were scored using this guide. The maximum score that could be assigned was 46.

Multiple data sources were used in this study that included pre-study interviews, pre- and post-lesson interviews, lesson observations and students' unit pre- and posttest scores. These data sources provided the necessary information to best answer the research questions associated with this study, which aimed to examine the nature of four fourth-grade teachers' adaptations while teaching and during planning when implementing the *FOSS* "Magnetism and Electricity" unit, with particular focus on the nature of teachers' vision-linked adaptations and the nature of the relationship between teachers' vision-linked adaptations and students' science learning. In this section, I provided a description of each data source that contributed to this inquiry. In the next section a description of the data analysis is provided.

Data Analysis

To analyze the data collected during pre- and post-lesson interviews and lesson observations, (teachers' adaptations made while planning and during teaching), I and two other researchers, coded teachers' adaptations and rationales made while teaching using the TAT adaptations and rationales codes established by previous researchers (see Tables 1 and 2 in Chapter I). We also coded teachers' rationales for the adaptations they made during planning, using the rationale codes provided by previous TAT researchers. Teachers' adaptations made during planning were coded based on how the teacher indicated she was adapting during the pre-lesson interview but was not included in the analysis unless she enacted the adaptation while teaching (see Table 4). Frequency counts of all four teachers' adaptation and rationale codes were completed and displayed in tables. This analysis process allowed me to determine the nature of, or the types of, teachers' adaptations while teaching and during planning when implementing the *FOSS* "Magnetism and Electricity" unit.

Teachers' vision statements (documented in pre-study interviews) were analyzed so that features of teachers' vision could be determined. I examined the pre-study interviews and extracted the features of teachers' visions based on what they articulated. That is, for each teacher, I determined the features of her vision. The features that were identified from this analysis, served as criteria to compare teachers' adaptations and rationales so that teachers' vision-linked adaptations could be identified. When an adaptation seemed to be vision-linked, I examined the associated rationale. If the rationale appeared to indicate that the teacher was enacting her vision through the adaptation that she made, then I corroborated the rationale with the feature of the teacher's vision and her vision that she articulated during the pre-study interview. All of the adaptations and all of the associated rationales were treated as potential vision-linked adaptations. When a teacher provided a rationale that indicated she was enacting a particular feature of her vision, and was corroborated by her responses during the pre-study interview, then the adaptation was coded as a vision-linked adaptation. Teachers' vision-linked adaptations were transformed into frequency counts and displayed in crosstab tables provided in the Statistical Package for the Social Sciences (SPSS). These processes of analysis allowed for an accurate, in-depth understanding of the nature of teachers' vision-linked adaptations and therefore, could be described.

Target students' unit pre- and posttest results, (which were scored by me, based on the curriculum materials scoring guide) were used to assess target students' science learning. After target students' tests were scored, I calculated the gain score for each student (as previously described). These data were displayed in crosstabs tables provided in SPSS. Further, these data were compared with the results of the data analysis of teachers' vision-linked adaptations. Additionally, a Pearson's correlation coefficient between the frequency counts of teachers' vision-linked adaptations and target students' posttest scores was calculated to determine if a significant relationship existed between teachers' vision-linked adaptations and students' science learning and if so to determine the strength of that relationship. The processes of data analysis described here allowed me to determine the nature of the relationship between teachers' vision-linked adaptations and target students' learning.

Following these data analysis procedures allowed me to best answer the research questions in this study. Table 8 provides a summary of the data analyses procedures for each data source. Next, I discuss how I ensured trustworthiness of this research.

Table 8

Summary of Data Analyses Procedures

<table>
<tr><th>Research Question</th><th>Data Source</th><th colspan="2">Analysis</th></tr>
<tr><td rowspan="3">What is the nature of four fourth grade science teachers' adaptations while teaching and during planning when implementing the FOSS "Magnetism and Electricity" unit?</td><td>Pre-lesson Interview</td><td rowspan="3">TAT Codes for Adaptation and Rationale Types</td><td rowspan="3">SPSS Frequency and Crosstabs</td></tr>
<tr><td>Lesson Observation</td></tr>
<tr><td>Post-lesson Interview</td></tr>
<tr><td rowspan="2">What is the nature of the four fourth grade teachers' vision-linked adaptations?</td><td>Pre-Study Interview</td><td colspan="2" rowspan="2">SPSS Frequency and Crosstabs</td></tr>
<tr><td>Vision Features</td></tr>
<tr><td rowspan="3">What is the nature of the relationship between four fourth grade teachers' vision-linked adaptations and students' science learning?</td><td>Vision-linked Adaptations</td><td colspan="2" rowspan="3">SPSS
Correlation Analysis</td></tr>
<tr><td>Unit Pre- and Posttest Scores</td></tr>
<tr><td>Gain Scores</td></tr>
</table>

Trustworthiness

Four aspects of trustworthiness in qualitative research have been identified: credibility, transferability, dependability, and confirmability (Maxwell, 1996; Miles & Huberman, 1994; Toma, 2006). Credibility refers to the degree to which the researcher accurately represents the phenomena under study. In this study, I ensured credibility by audiotaping and transcribing all of the interviews conducted. Also, every adaptation was verified with the teacher (i.e., member checking) as was the features of her vision that were identified.

Lincoln and Guba (1984) recommend that qualitative researchers promote transferability by providing a “thick description” (p. 126) of the context so that others can ascertain whether the research context is similar to their own context. Further, Borko, Liston, and Whitcomb (2007) and Toma (2006) suggest that the researcher is responsible for providing detailed descriptions of the context, and that the reader is responsible for determining the degree of transferability to their setting. Therefore, I provided an in-depth description of the context that I conducted this study in so that others may determine the extent to which my findings are applicable to their situation.

Dependability refers to the extent to which the research is stable. Creswell (2003) indicates that qualitative research may be refined as data is collected while Miles and Huberman (1994) warn that a study’s design and procedures should be consistent throughout the research. Accordingly, in this study, I promoted dependability by defining clear research questions, using a clear theoretical framework to guide the study, studying multiple cases, and collecting the same data across all four cases. For example, I used the same: pre-study interview protocol (see Appendix A) for all pre-study interviews, pre-lesson interview protocol (see Appendix B) for all pre-lesson interviews, lesson observation protocol (see Appendix C) for all lesson observations, post-lesson interview protocol (see Appendix D) to guide all of the post-lesson interviews.

Confirmability indicates that the researcher took measures to limit the biases. To this end, I confirmed adaptations made during planning through lesson observations and adaptations made while teaching during post-lesson interviews. Whether or not a teacher's adaptation was identified as vision-linked was confirmed if the rationale for the adaptation was reflective of the teachers' language used to describe their visions for teaching. These efforts were made to limit my bias in the data I collected and the findings I inferred. To ensure rigor in this study I took measures to promote credibility, transferability, dependability, and confirmability, and therefore provided trustworthiness of this research conducted.

This chapter has provided the methodological considerations for this study. The research site, participants and design of this study were described. The conceptual framework, research procedures and data analysis process used in this study were identified and discussed. The ways in which I ensured trustworthiness of this research were presented.

Chapter IV presents the findings and a discussion of the findings for this study.

CHAPTER IV

FINDINGS AND DISCUSSION

The purpose of this study was to examine four fourth grade teachers' instructional adaptations made while teaching and during planning when implementing the *Full Option Science System* (*FOSS*) "Magnetism and Electricity" unit. I was especially interested in teachers' instructional adaptations that were linked to their visions of teaching. An additional purpose of this study was to explore the nature of the relationship between teachers' vision-linked adaptations and their students' science learning, defined narrowly by selected students' scores on the FOSS "Magnetism and Electricity" unit posttest.

This study was conducted and the data analyzed using an interpretative multiple case study, mixed methods approach. Data collected included teachers' comments made during a pre-study interview, 13 pre-lesson interviews per teacher, 13 lesson observations per teacher, and 13 post-lesson interviews per teacher. Unit pre- and posttest scores were analyzed for 23 target students.

This chapter details and discusses the findings of the study. I highlight the significant results and reflect on their contribution to TAT research. A discussion that explores why the results may differ from previous TAT studies is embedded in the presentation of the findings.

First, the overall findings with respect to frequencies of adaptations and rationales made during teaching and planning are presented and discussed. The next part of this chapter is organized by case and is limited to discussion of vision-linked adaptations. In this part of the chapter, I describe each teacher's vision-linked adaptations and the teacher's target students' learning. After all of the cases have been presented, I describe and discuss the nature of the relationship between teachers' vision-linked adaptations and students' learning as measured by the pre and posttests. This chapter concludes with a summary of the major findings of this study.

Overall Findings

All Adaptations and Target Students' Learning

In Table 9, we see that teachers in this study made many adaptations while teaching ($N = 215$) and during planning ($N = 70$). Overall, 75% of the adaptations occurred while teaching and 25% occurred during planning. The teachers made 156 vision-linked adaptations (55% of the total number of adaptations); 125 (80%) while teaching, and 31 (20%) during planning. The same general pattern of more vision-linked adaptations made while teaching (75-80%) than while planning (25-20%) held. Another pattern apparent in the findings was that the more adaptations that individual teachers made, the higher their students' performance on the posttest. The same is true of the sub-set of vision-linked adaptations: the more vision-linked adaptations that teachers made, the higher their students' performance on the posttest.

Table 9

Frequency of Teachers' Adaptations and Vision-linked Adaptations Made While Teaching and During Planning and Mean Scores for Target Students' Unit Pre- and Posttests

	Total Adaptations			Vision-linked Adaptations			Mean % Correct for Target Students		
Teacher	**Teaching**	**Planning**	**Total**	**Teaching**	**Planning**	**Total**	**Pretest**	**Posttest**	**Gain**
Landers	37	12	49	16	4	20	48%	54%	10%
Lawson	59	23	82	32	7	39	48%	65%	14%
Rose	64	13	77	52	8	60	52%	72%	41%
Winn	55	22	77	25	12	37	57%	72%	32%
Total	215	70	285	125	31	156	51%	66%	24%

Teachers' Vision-linked Adaptations across Lessons

When we examine only vision-linked adaptations made during planning and while teaching across all 13 lessons and all four teachers (see Table 10), it appears that vision-linked adaptations were made more frequently about mid-way through the unit implementation. Beginning with lesson number seven through lesson number 13, there was an increase in the frequency of vision-linked adaptations that teachers made. It was during these lessons that teachers provided students with the necessary materials to build parallel and series circuits, investigate open and closed circuits, test items as conductors and insulators and build and investigate ways to increase the strength of an electromagnet, all relatively open tasks. As teachers provided relatively open tasks for students, the frequency of their overall adaptations increased as well as the frequency of their vision-linked adaptations. In Table 11, the frequency of adaptations made for each lesson during teachers' implementation of this unit is represented. Across 52 science lessons, four teachers made 285 adaptations.

Table 10

Frequency of Teachers' Vision-linked Adaptations Made During Planning and While Teaching Across All Lessons

Teacher	Lesson Number													Total
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	
Landers	3	0	1	3	1	3	0	0	1	2	1	1	4	20
Lawson	3	1	3	1	0	0	5	5	7	1	4	2	7	39
Rose	6	3	4	4	3	3	4	6	1	6	9	5	6	60
Winn	4	2	3	1	1	1	0	2	1	5	4	9	4	37
Total	16	6	11	9	5	7	9	13	10	14	18	17	21	156

Table 11

Frequency of All Adaptations Made during Planning and While Teaching Across Lessons

Teacher	Lesson Number													Total
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	
Landers	6	5	4	2	1	5	3	3	4	4	5	3	4	49
Lawson	11	13	4	4	2	4	7	7	10	2	5	3	10	82
Rose	9	3	4	5	3	4	4	8	2	7	11	8	9	77
Winn	8	8	5	5	2	6	0	5	2	8	8	13	7	77
Total	34	29	17	16	8	19	14	23	18	21	29	27	30	285

All Adaptations Made across Lessons while Teaching and during Planning

The teachers in this study made many more adaptations per lesson ($M = 5$) than the teachers in previous TAT studies ($M = 2$), an average of less than one adaptation per lesson, which all focused on literacy (Parsons et al., 2010) (see Table 12). Even though I examined adaptations made during planning and while teaching across a unit of instruction (*FOSS, "*Magnetism and Electricity") only about 25% ($N = 70$) of the adaptations made in this study were made during planning and therefore the addition of adaptations made during planning cannot account for this increased frequency.

Table 12

Comparison of Frequencies of Adaptations Made during Science and Literacy Lessons

Comparison Criteria	Science	Literacy
Number of Teachers	4	24
Number of Lessons	52	154
Number of Adaptations	285	353
Mean Adaptations	5	2

Important factors to consider that may account for some of the differences between the frequencies of adaptations in this study as compared to previous TAT studies may be found by examining adaptations at the level of the lesson. An analysis across the 13 lessons in this study showed that the four teachers in this study collectively made an average of 22 adaptations per lesson. However, this analysis also revealed that the frequency of adaptations steadily decreased from lesson one (N = 39) through lesson five (N = 8). After lesson five, the frequency of adaptations increased with each lesson through the last lesson, lesson 13, in the unit (N = 30). Comparisons across the content of the lessons indicated that as teachers implemented lessons with a more open approach to inquiry, they made more adaptations (see Appendix G for lesson content summaries).

For example in lesson one, 34 total adaptations were made. In this lesson, the teachers provided students with a variety of test items and a magnet and asked students to determine which items were attracted to magnets and which times were not attracted to magnets. Students were also allowed to explore other objects in the classroom to determine if they were attracted to magnets or not. This lesson offered students opportunities to share their findings with their groups and with the whole class. Teachers led students to make conclusions about the properties of the materials that were attracted to magnets. Using Windschitl's (2003) taxonomy to identify science lessons on an inquiry scale, ranging from confirmation to structured inquiry to guided inquiry to open inquiry, this lesson was characterized as guided inquiry (Windschitl, 2003). That is, for this lesson, the teachers provided the purpose and the materials for the exploration but allowed for students' further explorations and encouraged students to make meaning of their findings through discussion with their peers and the teacher.

Lesson number 13 was also characterized as a guided inquiry approach to science instruction. In this last lesson of the unit, teachers allowed students to continue (from lesson number 12) their exploration about how to build an electromagnet and once they accomplished the task, they were to figure out how to make the electromagnet stronger. As with lesson number one, teachers provided the purpose for the investigation but did not limit students' uses of materials or approaches to the task. Consequently, teachers made 30 adaptations in this lesson. Both lesson numbers one and 13 were taught with a more open approach to inquiry in the form of guided inquiry than lesson number five that was taught as a matter of confirmation experience.

For instance in lesson number five, teachers involved their students in a discussion about establishing procedures for an investigation about the number of washers that would be needed to "break the force of magnetism." However, all four of the teachers had specific plans about the question that would be investigated (How many washers does it take to break the force of magnetism?), the procedures (how to set up the materials for the investigation so that all the groups would be collecting the same data in the same manner) and the way students would display the data they collected on a bar graph. During this lesson, teachers directed their students towards the question and procedures for the investigation that they planned and remained committed to their plans while they taught the lesson, rather than allowing students to pursue their own questions or make decisions about the best ways to set up the investigation or display the data collected. Lesson number five mimicked a confirmation experience approach to inquiry where teachers provide the questions and procedures for the inquiry (Windschitl, 2003). Consequently, teachers did not make very many adaptations for this lesson ($N = 8$).

It appeared that as teachers used a more open approach to inquiry in science, the teacher also became more adaptive. This finding is similar to Parsons' (2008) findings in his study of TAT and openness of tasks. The more open the task that teachers provided for students, the more adaptations teachers made. The nature of the subject matter (science vs. literacy) may warrant that more adaptations be made in science. Perhaps the science tasks that teachers involve their students with are typically more open than those associated with literacy, making it necessary to make many more adaptations. The frequencies of adaptations found in this study may have occurred in part because this study was conducted in the context of science rather than literacy.

Other factors that may have contributed to the differences in the number of adaptations found in this study may include methodological procedures such as the pre-lesson interview where adaptations during planning were noted and the timing of the pre-lesson interviews, which may have triggered teachers to think more deeply about teaching and subsequently make more adaptations while teaching. Likewise, procedures used during lesson observations and post-lesson interviews may also have triggered more thoughtful reflection by teachers, which resulted in more adaptations during planning and while teaching. Procedures used in the TAT studies with a literacy focus were different from procedures used in this study of TAT in science.

For example, in this study, pre-lesson interviews were conducted to find out what the teacher was planning to teach and to ask about adaptations made during planning and the associated rationales. In the previous TAT studies, researchers were only concerned with adaptations made while teaching and therefore did not conduct pre-lesson interviews but instead collected and analyzed the teachers' lesson plans. Conducting pre-lesson interviews in this study about what teachers would be teaching, their planned adaptations and rationales for the adaptations made during planning, perhaps influenced teachers in this study to think more deeply about their teaching, resulting in more observed adaptations.

Further, the timing of the pre-lesson interviews may have influenced teachers' reflections on lessons, which then impacted subsequent adaptations. For example, for 10 of the 13 lessons, pre-lesson interviews were conducted immediately following post-lesson interviews, which may have impacted teachers' engagement in reflection and therefore teachers more readily recognized a need to make adaptations during planning and while teaching. Pre-lesson interviews in this study may have provided the space for teachers to think about their lessons and teaching in ways that were not provided for in previous TAT studies and therefore, more adaptations may have been made as a result of teachers' focused thinking.

Another way this study differed in methodology from previous TAT studies that also may be related to the frequencies of adaptations found was the way in which I conducted lesson observations. During lesson observations for this study, I scripted as much as possible about what was happening in the lesson while also noting adaptations. Previous TAT researchers used the teachers' lesson plans to help identify adaptations while conducting lesson observations and noted only an adaptation if the teacher diverted from the lesson plan, responded to an unanticipated student contribution, or made a public statement of change and although in both studies teachers confirmed or denied researchers' interpretations of whether or not a particular change that was noted during the lesson observation was an adaptation or not, it is possible that through the process of scripting the lesson observation, more adaptations were identified and therefore, confirmed by the teacher.

In summary, I may have found more adaptations in this study compared to previous TAT studies because of a combination of factors that might include the following:

- The nature of the subject matter, science versus literacy, and the openness of tasks associated with science versus literacy may have allowed for more adaptations to be made.

- Interacting with teachers for pre- and post-lesson interviews during their implementation of a focused unit of instruction may have prompted teachers to think in ways that they were not prompted to think in previous studies.

Types of Adaptations Made in Regards to Thoughtfully Adaptive Teaching

Researchers (Duffy et al., 2006, 2008; Parsons et al., 2010) who have studied TAT in the context of teachers' literacy instruction have generated a list of adaptations that seem to occur across teachers across literacy content (see Table 13 for types). In conducting this study of adaptations that teachers made while teaching science I found that all of the adaptations made by teachers while teaching science were the same types of adaptations made by teachers while teaching literacy. This finding supports the use of thoughtfully adaptive teaching adaptation types as a way to examine teachers' adaptive practices across curriculum areas (see Table 13).

Table 13

Frequency of Thoughtfully Adaptive Teaching Adaptation Types Made While Teaching Science

Thoughtfully Adaptive Teaching Adaptation Type	Teacher				
The teacher…	Landers	Laws	Rose	Winn	Total
I – Modifies the lesson objective	0	2	1	1	4
II – Changes means by which objectives are met	15	46	27	31	119
III – Invents examples, analogy or metaphor	9	3	11	6	29
IV – Inserts a mini-lesson	0	1	4	0	5
V – Suggests a different perspective to students	6	0	8	3	17
VI – Omits/inserts Activity	7	7	8	13	35
VII – Changes planned order of instruction	0	0	5	1	6
Total	37	59	64	55	215

While the types of adaptations were comprehensive and inclusive of both literacy and science content, I did find that the frequencies of the types of adaptations that the science teachers in this study made while teaching varied from the frequencies of the types of adaptations that literacy teachers made while teaching in previous studies (Duffy et al., 2008; Parsons et al., 2010) (see Table 14).

Table 14

Thoughtfully Adaptive Teaching Adaptation Types Percentages Made While Teaching Science Compared to While Teaching Literacy

	Subject Area	
Thoughtfully Adaptive Teaching Adaptations Type	**Science**	**Literacy**
I – Modifies the lesson objective	2%	1%
II – Changes means by which objectives are met	56%	28%
III – Invents examples, analogy or metaphor	13%	37%
IV – Inserts a mini-lesson	2%	7%
V – Suggests a different perspective to students	8%	12%
VI – Omits/inserts Activity	16%	13%
VII – Changes planned order of instruction	3%	2%
Total	100%	100%

For example, this study revealed that while teaching science, teachers most often adapted their instruction by changing the means by which objectives were met ($N = 119$, ~56%), whereas in the Parsons et al. (2010) TAT meta-analysis study of literacy teachers' adaptations, this type of adaptation was only made about 28% of the time. The second most frequent type of adaptation that teachers made while teaching science in this study was that they either omitted or inserted an activity and this accounted for about 16% of the total adaptations made while teaching, which was similar to the 13% of adaptations of this type found in literacy studies of TAT. The third most frequent type of adaptation found in this study was that teachers invented an example, analogy, or metaphor that accounted for about 13% of the total adaptations made while teaching. However, this type of adaptation was most frequently represented in teachers' adaptations made while teaching literacy and accounted for about 37% of all the adaptations. Further, this study indicated that like previous TAT research, teachers adapt less frequently by suggesting a different perspective to students, inserting a mini-lesson, changing the planned order of instruction or by modifying the lesson objective (as opposed to changing the means by which the objective is met where the objective remains the same).

These differences may exist due to a number of reasons. The nature of how both science and literacy are taught may be one possible explanation. For example, inquiry as it was implemented in this study, often promoted that students conduct investigations with opportunities to construct their scientific knowledge and more deeply examine and question their ways of thinking. In the case of science inquiry, teachers chose to change or modify the activity or discussion rather than provide examples, as they often do in literacy instruction. Changing or modifying the activity (which signals an adaptation of changing the means by which the objectives were met), is a more logical option when one is aiming to promote inquiry. For example, in lesson number 11 (teachers introduced parallel circuits and had students create a circuit with two pathways for the flow of electricity) a student was convinced that there was something wrong with the wires that she was using to build the parallel circuit. Ms. Rose recognized that the orientation of the student's batteries was not correct and that the wires were not the problem and responded by first asking the student what made her think that the wires were not working. After the student responded that the light bulb would not light, Ms. Rose asked the student about a different way to check the wires and after a few more questions from Ms. Rose, the student eventually decided to test her wires on another group's working circuit. In this way, Ms. Rose maintained her objective but had to modify or change how she helped this student meet the objective. Providing an example in this case may have resembled Ms. Rose thinking out loud for the student so that the student would check that the orientation of the battery was correct. For instance, Ms. Rose may have said "I don't think the wires are working but I am not sure what can I do to check them? I have an idea, let me first check that my batteries are aligned properly." Then perhaps, she would proceed to check the battery alignment and explicitly point out how they were not aligned. Instead, Ms. Rose adapted (by changing the means by? which the objective was met) by prompting the student to engage in further inquiry. In literacy a common practice for teachers is to provide an example for their students by modeling their thinking in teacher think alouds with the intention of helping their students think about their thinking as they read. During this science unit I repeatedly observed the four fourth grade teachers encourage students to "continue their investigations" in order to find answers to their questions rather than provide examples of how to think or what to do. This response appears to be a common strategy unique to the discipline of science, especially when science instruction is approached from a stance of inquiry.

Another aspect of science vs. literacy instruction that may have accounted for the difference in frequency of adaptations is in how science and literacy teachers approach building students' background knowledge. In science, an investigation or doing science provides students with a common landscape of background knowledge. That is, by doing science, students are provided with experiences to assist with building their background knowledge and so rather than provide students with an example, it is more fruitful to change the activity or the means by which the objective is met. For example, in this study, students learned about circuits and then in one classroom a student connected his new knowledge of circuits to the toys he had at home, after he constructed knowledge of circuits by building circuits. Part of the beauty of science inquiry is that one can still do science with limited background knowledge.

In literacy however, we know that in preparing students to read, it is essential to activate their prior knowledge so that they may connect with the text and make meaning through those connections. So when teachers notice that students' background knowledge needs to be developed before reading or writing, the most logical response is to provide an example for students aiming to give them something that will activate their prior knowledge.

In the ways discussed above, the inquiry-based science instruction observed in the four teachers' classrooms was less explicit than what may be seen in literacy classrooms and therefore, the teachers in this study, changed the means by which the objectives were met, instead of providing examples for students.

The teachers in this study appreciated the *FOSS* curriculum materials provided for teaching a unit on magnetism and electricity. All four of the teachers commented that having everything they needed to teach a lesson in one place and organized saved them time during planning for instruction. Teachers also commented that having the curriculum materials helped them with their own content knowledge so that they could be better prepared to teach the lessons. All four of the teachers in this study had used these materials before, so they were familiar with the resources and the lessons. All of these components combined seemed to foster an appreciation among teachers in the study in regards to using the curriculum materials.

While the teachers in this study embraced the benefits associated with the curriculum materials (materials readily available, assisted with content knowledge and familiarity), it is also important to note that they were not bound to strictly adhere to curriculum materials as a script for instruction. Rather, the norms and rules within the school allowed for teachers to make their own decisions about how to use the curriculum materials. Teachers in this study were free to exercise their autonomy in ways that teachers may not have been in previous TAT studies. For example, Parsons, et al noted that 30% of the teachers in the TAT literacy studies "were using restrictive literacy programs" (p. 4) and so therefore, did not likely have the autonomy to change the means by which the objectives were met (from the restrictive literacy program) and instead had to rely on providing examples for students.

Types of Rationales Provided for Adaptations Made

As was the case with categories of adaptations, researchers (Parsons et al., 2010) who have studied TAT in the context of teachers' literacy instruction generated a list of rationales that were provided for the adaptations made across teachers and literacy content. I found that all of the rationales provided by teachers for the adaptations they made while teaching science were the same rationales made by teachers while teaching literacy. This finding supports the use of thoughtfully adaptive teaching rational types as a way to examine teachers' rationales for the adaptations they make across curriculum areas (see Table 15).

Table 15

Frequency of Thoughtfully Adaptive Teaching Rationales Made While Teaching Science

	Teacher				
Thoughtfully Adaptive Teaching Rationale	**Landers**	**Laws**	**Rose**	**Winn**	**Total**
A – Objectives not met		2	2		4
B – Challenge/Elaborate	2	3	5	3	13
C – To teach a specific strategy or skill	5	6	4	4	19
D – To help students make connections	11	19	18	8	56
E – Uses knowledge of students or classroom dynamics to alter instruction	5	10	11	17	43
F – Checking students understanding	4	11	12	6	33
G – Anticipation of upcoming difficulty	1	2	4	5	12
H – To manage behavior	3	1	1	3	8
I – To manage time	5	2	2	5	14
J – To promote student engagement	1	3	5	4	13
Total	37	59	64	55	215

In this study, the rationales that most frequently occurred (61% of the total rationales) were coded: (a) to help students make connections, (b) to use knowledge of their students or classroom dynamics to alter instruction, and (c) to check students' understanding. The top three rationales offered in TAT studies of literacy teachers indicated that about 58% of their adaptations were coded: (a) because objectives were not met, (b) to help students make connections, and (c) to use knowledge of their students or classroom dynamics to alter instruction (see Table 16).

Table 16

Comparison of Rationales for Adaptations Made While Teaching and During Planning for Science and While Teaching During Literacy

Thoughtfully Adaptive Teaching Rationale	Science	Literacy
A – Objectives not met	1%	27%
D – To help students make connections	20%	18%
E – Uses knowledge of students or classroom dynamics to alter instruction	15%	13%
F – Checking students understanding	12%	3%

Interestingly, science teachers in this study rarely provided the rationale, "*because the objective was not met*" for making an adaptation while teaching; yet, this was the most frequent rationale provided by teachers in previous TAT studies. Perhaps since the science teachers in this study most frequently adapted by changing the means by which objectives were met (about 55% of the time) students met teachers' objectives of the lessons and so this type of rationale was not needed. Or perhaps, since teachers were frequently making adaptations with rationales that indicated that they were trying to help students make connections, using their knowledge of students and checking students' understanding, it stands to reason that their lesson objectives might have been met and therefore, teachers rarely cited this as a rationale for adapting while teaching.

Adaptations Made During Planning for Science Instruction

With respect to the adaptations made during planning, there were four pre-established categories used for this study (see Table 17). The adaptations made most frequently during planning were teachers' modification of the curriculum materials from the way they had taught the lesson in the past (see Table 17). Given that all the teachers reported at the beginning of this study that the only expectation of them for teaching science was that they use the kits during a scheduled time to teach science, it was not a surprise that the most common adaptation made during planning was a modification from the materials. Teachers in this study were afforded the opportunities to use the materials in ways they deemed necessary.

Table 17

Frequency of Adaptations Made During Planning

Adaptation Made During Planning for Science Instruction	Teacher				Total
	Landers	Laws	Rose	Winn	
Modification of district or school requirement	2	0	1	0	3
Modification of Materials	9	10	6	11	36
How the lesson has been done in the past	1	12	6	11	30
Change in Instructional Strategies	0	1	0	0	1
Total	12	23	13	22	70

The finding that adaptations were also made frequently from how the lesson had been taught in the past may indicate that teachers have not always approached science in the ways that they did during this study or that teachers were still navigating to find the best ways to implement the unit. Perhaps, too, engaging in post-lesson interviews immediately following lesson observations encouraged teachers to reflect on the lesson. Perhaps during these interviews, teachers realized that changes needed to be made and adapted from how they had taught the lesson in the past. It is also noteworthy that these four rationale categories were established before the study and it is possible that these categories, upon refinement, may yield different results. For example, if teachers were asked, “What particular adaptations are you making during planning for tomorrow’s lesson?” instead of “Is what you are doing for tomorrow’s lesson in any way a modification of (a) district or school requirements, (b) the way the curriculum materials suggest the lesson, (c) how you have done the lesson in the past, (d) instructional strategies?,” then their responses could be elaborated upon to further understand the adaptations that teachers make during planning. In other words, if more open-ended questions were asked about how teachers adapted during planning, other adaptations might have emerged. However, I used the established interview protocol as described above in each of my post-lesson interviews.

Types of Rationales Made for Adaptations during Planning

Using previously established TAT rationale types for the adaptations that teachers made during planning (see Table 18), the findings of the study indicated that teachers were most concerned with managing time ($N = 21$). Perhaps for these teachers, it was more suitable to plan instruction well with attention to the limits of their scheduled thirty-minute science block so that they could provide students with what they perceived as the most important experiences related to the unit. Teachers were also concerned with helping students make connections (*N* = 17). Interestingly, while teaching, teachers most frequently adapted to help students make connections, which may indicate that they planned for ways to help students make the connections they saw as necessary and that they were also thinking about helping students make connections while they were teaching.

Table 18

Frequency of Thoughtfully Adaptive Teaching Rationales for Adaptations Made During Planning

Thoughtfully Adaptive Teaching Rationale Code	Teacher				Total
	Landers	Laws	Rose	Winn	
A – Objectives not met	0	0	0	0	0
B – Challenge/Elaborate		2	1	1	4
C – To teach a specific strategy of skill			1	1	2
D – To help students make connections	1	10	2	4	17
E – Uses knowledge of students or classroom dynamics to alter instruction		3	3	6	12
F – Checking students understanding		2	1	2	5
G – Anticipation of upcoming difficulty			1	4	5
H – To manage behavior	0	0	0	0	0
I – To manage time	11	4	3	3	21
J – To promote student engagement		2	1	1	4
Total	12	23	13	22	70

Overall Findings in Regards to Thoughtfully Adaptive Teaching Rationales for Adaptations Made While Teaching and During Planning

When the frequency of thoughtfully adaptive teaching rationale types are combined for all 285 adaptations teachers made while teaching and during planning (see Table 19), teachers indicated that they were mostly concerned with: (a) helping students make connections, (b) using knowledge of students or dynamics of the classroom, (c) managing time, and (d) checking students' understanding. Collectively, these rationales accounted for about 70% of the rationales provided.

Table 19

Frequency of Thoughtfully Adaptive Teaching Rationale Types for Adaptations Made While Teaching and During Planning

Thoughtfully Adaptive Teaching Rationale Type	Teacher				Total
	Landers	Laws	Rose	Winn	
A – Objectives not met	0	2	2	0	4
B – Challenge/Elaborate	3	5	6	6	20
C – To teach a specific strategy of skill	5	6	5	5	21
D – To help students make connections	13	22	18	12	65
E – Uses knowledge of students or classroom dynamics to alter instruction	4	15	17	23	59
F – Checking students understanding	4	14	10	8	36
G – Anticipation of upcoming difficulty	1	2	6	5	14
H – To manage behavior	3	1	1	2	7
I – To manage time	14	8	5	11	37
J – To promote student engagement	2	7	7	5	21
Total	49	82	77	77	285

Summary of the Overall Findings with Respect to Adaptations and Rationales

To summarize, the general findings of this study were:

- teachers made adaptations during planning (although not nearly as frequently as while teaching) and a subset of these adaptations was vision-linked,
- when lessons were more inquiry-based with open tasks for students' to complete, teachers made more adaptations and more vision-linked adaptations,
- there appears to be a relationship between teachers' adaptations and vision-linked adaptations and students' immediate science learning, which is further discussed in detail within the cases of teachers that follow, and
- even though literacy and science teachers adapt in different ways, they provide similar rationales for making adaptations

The next section of this chapter provides the findings and discussion related to teachers' vision-linked adaptations. I begin with an overall summary of the features of teachers' visions, highlighting the features of their visions across all four teachers. Then, organized by teacher, I provide the results of how each teacher's vision-linked adaptations were related to previously identified TAT adaptations and rationales. Within each section, by teacher, I provide a profile of the nature of the relationship between the teacher's vision-linked adaptations and her target students' science learning, as represented by scores on the *FOSS* "Magnetism and Electricity" unit posttest.

Features of Teachers' Visions

Across all four teachers, there were 15 features of teachers' vision that emerged from the analysis of the content of their vision statements (see Table 20).

Table 20

Features of Teachers' Visions Articulated During the Pre-study Interview

Feature	Landers	Lawson	Rose	Winn
Students possess independence	X		X	X
Students experience a positive school/classroom environment	X	X	X	
Students possess confidence	X	X		X
Students possess a positive disposition for learning	X		X	
Students figure out or discover how things work	X	X		
Students use evidence from experimentation to justify decisions	X			
Students engage in and are motivated for inquiry	X		X	
Students persist	X	X		X
Students possess self-awareness of their strengths		X	X	
Students possess an awareness of or application to the real world	X	X	X	X
Students possess an awareness that all learning is interconnected		X		
Students possess multiple ways to solve problems		X		X
Students learn science outlined in the North Carolina Standard Course of Study			X	X
Students work collaboratively and cooperatively			X	
Students pursue interests				X

All four teachers shared the hope that their students would become aware of how their learning related to or could be applied to the real world. Four features were the same among three of teachers and included that they wanted students to become independent, to be able to experience a positive school or classroom environment, and to become confident and persistent in the face of difficulty.

It is important to note that as teachers articulated their visions for teaching during the pre-study interview, they all seemed to possess an image of the purpose of teaching deeply rooted in their personal convictions of *what could be* if students were able to become all the things they discussed. These personal convictions seemed to provide each teacher with what Korthagen (2004) described as a sense of mission. They also appeared to be emotionally invested in their teaching. For example, while describing what they perceived as students' limited opportunities to learn about the world outside of school, the teachers were in tears or near tears as they indicated that they wanted their students to know of all the possibilities beyond what they see now. They wanted students to be aware of higher education opportunities within miles of their community. It appeared, like others have indicated, that for the teachers in this study, they perceived teaching as a calling (Hansen, 1995; Huebner, 1987).

The pre-study interviews revealed that while there were some shared features of teachers' visions, several features were unique to each teacher. Further, all four teachers shared the belief that science should be taught through inquiry and that inquiry included hands-on opportunities for students to work together in small groups to 'figure out or discover something.' Like the features of their visions, each teacher's description of how she orchestrated these opportunities varied.

Teacher Cases

Previous TAT research (Duffy et al., 2008; Parsons et al., 2010) has provided ways to code the adaptations and rationales that teachers provide when they make adaptations while teaching literacy. The frequency counts associated with these studies have also contributed to our understanding of how often certain types of adaptations are made and particular rationales are provided. However, we still have a very limited understanding about exactly what teachers do when they adapt and the circumstances surrounding the adaptations they make and whether or not the adaptations they make seem to results in a difference in terms of students' learning. Additionally, it has been suggested that thoughtful teachers possess a vision for teaching (Fairbanks et al., 2010). This study addressed these gaps and aimed to better understand teachers' vision-linked adaptations and the nature of the relationship between their vision-linked adaptations and their students' learning.

The following results of the study are presented as teacher cases. Within each case, the content of the teacher's vision is described. Included in these descriptions are teachers' reasons for becoming teachers, hopes of what they want to accomplish as a teacher and what they aim for students to learn and become. In regards to teaching towards their vision, the barriers they identified during the pre-study interview are also described. While this dissertation did not include an examination of the influence or relationships of teachers' perceived barriers, that information is included here because it is helpful in understanding the context in which these teachers were working. Within each case, I present the features of each teacher's vision that were represented in the vision-linked adaptations that she made as they compare to TAT adaptation and rationale types. Next, I provide a description of the teacher's vision-linked adaptations. Then, I discuss the results of the teacher's target students' learning. After all four cases are presented, I describe the nature of the relationship between teachers' vision-linked adaptations and students' learning.

Ms. Landers—Empowering Students to Engage in Inquiry and Figure Out How Things Work

Ms. Landers became a teacher because she values the opportunities to develop relationships with students. During the pre-study interview she shared a story about her second grade teacher receiving a cupcake from a former student. Even then, when she was a second grader, Ms. Landers knew that she wanted to be a teacher; she wanted to earn the coveted cupcake. Ms. Landers recalled, "The first time I decided to become a teacher I was in second grade and my teacher got a cupcake from someone else in another class. I wanted a cupcake and she told me that the only way I could get one was if I was a teacher, so I thought okay, I want to be a teacher."

As Ms. Landers became older, she pursued teaching as a career for more significant reasons than being rewarded with a cupcake. Although she distinctly remembered this event she now attributes this sort of affection shown by students as an indicator that they love their teacher. Ms. Landers stated, "I realized that she got that cupcake because they loved her so much when she had them! And I want to have that relationship with students. I've always wanted to be that for somebody."

A glimpse into why Ms. Landers chose to become a teacher assists with understanding a portion of her vision for teaching. Representing what Zembylas (2003) refers to as the emotional aspect of teacher visioning, part of Ms. Landers' vision for teaching is her desire to build positive relationships with students. Although developing positive relationships with students is certainly beneficial for students, Ms. Landers' responses indicated that her reasons for becoming a teacher are rooted in her pursuit of personal and emotional rewards.

However, when Ms. Landers was asked about what she hopes to accomplish as a teacher, all of her responses reflected goals that she held for students. For example, she stated, "I want students to understand that grownups aren't always right and if they [students] have knowledge then they can be independent." She further stated, that she wanted students to "feel confident and supported," "understand that there is more opportunity for you if you are knowledgeable about things," "learn how to approach the world," "be proud of themselves" and "be responsible." She also expressed that she wanted her students to be motivated and confident learners who "never stop wanting to know" and to have the ability to intelligently discuss various issues.

Ms. Landers indicated that she tries to enact her vision everyday and provided the following examples. She reported "letting students say their opinions and I'll disagree with it on purpose and I'll word it like—'you know that sounds good but what about this?' I do this because they need to hear how to properly disagree with somebody and that it is okay to disagree but you have to do it in a kind way. I always tell them to be kind."

Another example she offered was when she referred to the classroom as “ours” and described her approach of promoting a classroom environment “where it is okay to be who you are.” She reported that she frequently points out her own mistakes, hoping to relay the message to students that mistakes are acceptable. She also provided details about how she specifically deals with students who realize that they need additional assistance in math. She stated, “I have a couple of students who ask if they can go in another group because they feel like they need more practice with particular skills. I think that shows that they feel okay about that.”

In the area of science she indicated that she promoted inquiry. For example, she prefers to let students “figure things out on their own.” However, drawing on prior experiences, she pointed out that some students “get frustrated if they don’t know the answer right away.” Yet, she believed that “Science should be experiments and things that they can try and figure out.” Ms. Landers acknowledged that she has to “help students make those connections through a conversation—and talk them through the inquiry so they can figure it out.” She further explained that she likes for students to do group work and see different ways to do things and that after completing the inquiry portion of a lesson she holds a “big discussion about how they did things differently and how it was different than what they thought.”

Ms. Landers indicated that the varying personalities of her students sometimes made it difficult to enact her vision. To manage this, she had to be “strategic” when grouping students and needed to “make sure students have a clear picture of what they are suppose to do” so that they could work effectively within their group.

When asked about the specific goals she held for students' learning as a result of teaching this unit, Ms. Landers stated, "Of course, the content and I want them (students) to make connections about something they see—like connections to the real world. Also, I want them (students) to see the relevance to energy saving and to appreciate how things work and on a broader picture to be able to justify things through their experiments and be ok with not knowing the answer right away and wanting to do the inquiry."

Features of Ms. Landers's vision. As articulated during the pre-study interview, Ms. Landers most consistently focused on students to develop a positive disposition towards learning (confidence, love of learning, proud, comfort with not knowing). The goals she held for students' learning included the content of the FOSS unit and the relevance of energy conservation. She also held goals for students' persistence and independence, which she also connected to the students' real world future. Her goal for students' to understand the relevance of energy conservation also served as another avenue to connect students' learning to the real world. She further wanted students to be motivated to learn and to participate in inquiry, or figure out how things work. Her conceptions of how to approach inquiry indicated that she preferred that students work together in small groups with hands-on opportunities to explore while she guided their inquiry. After which, she leads a whole-class discussion to facilitate students' reflections about what they learned and how their approaches were different. The features of Ms. Landers' vision that she articulated during the pre-study interview are represented in Table 21.

Table 21

Features of Ms. Landers's Vision

Students possess independence
Students experience a positive school/classroom environment
Students possess confidence
Students possess a positive disposition towards learning
Students figure out or discover how things work
Students use evidence from experimentation to justify decisions
Students engage in and are motivated for inquiry
Students persist
Students possess an awareness of or application to the real world

Vision-linked adaptations and rationales in regards to thoughtfully adaptive teaching adaptations and rationales. Ms. Landers most frequently made vision-linked adaptations while teaching ($N = 16$) (see Table 22). Two features of her vision were promoted in about 75% of the vision-linked adaptations that she made (while teaching and during planning), that students (a) figure out how things work ($N = 7$), and (b) engage in inquiry ($N = 8$). When Ms. Landers made vision-linked adaptations while teaching, she most often changed the means by which the objectives were met ($N = 5$), invented an example, analogy or metaphor ($N = 4$), and omitted or inserted an activity ($N = 4$) that all together accounted for 81% of the TAT types of adaptations that represented her vision-linked adaptations while teaching.

Ms. Landers's rationales indicated that the vision-linked adaptations that she made while teaching and during planning were associated with helping students make connections ($N = 9$), and to manage time ($N = 5$), which together accounted for about 70% of the TAT rationale types for the vision-linked adaptations that she made (see Table 23).

Table 22

Features of Ms. Landers's Vision Represented in Vision-linked Adaptations Made While Teaching and Thoughtfully Adaptive Teaching Adaptation Types

Feature of Vision Represented in Vision-linked Adaptations Made While Teaching	*TAT Adaptation Types				Total
	II	III	V	VI	
Students experience a positive school/classroom environment		1		1	2
Students figure out how things work	3	3			6
Students engage in inquiry	2		2	3	7
Students possess a positive disposition towards learning			1		1
Total	5	4	3	4	16

*TAT Adaptation Types: II – Changes means by which objectives are met; III – Invents examples, analogy or metaphor; V – Suggests a different perspective to students; VI – Omits/inserts Activity

Table 23

Features of Ms. Landers's Vision Represented in Thoughtfully Adaptive Teaching Rational Types

Feature of Vision	*TAT Rationale Types							Total
	B	C	D	E	F	I	J	
Students experience a positive school/classroom environment	1		1				1	3
Students figure out how things work		1	3		2	1		7
Students engage in inquiry			5	1		2		8
Students possess a positive disposition towards learning						2		2
Total	1	1	9	1	2	5	1	20

*TAT Rationale Types: B – Challenge/Elaborate; C – To teach a specific strategy of skill; D – To help students make connections; E – Uses knowledge of students or classroom dynamics to alter instruction connections; F – Checking students understanding; I – To manage time; J – To promote student engagement

Below is a description of how Ms. Landers adapted in accordance with her vision (while teaching and during planning) and the associated rationales that indicated she was promoting for students to engage in inquiry and for students to figure out how things work.

Promoting students' engagement in inquiry. Ms. Landers made adaptations to promote students' engagement in inquiry ($N = 8$) across six lessons (lessons 1, 3, 4, 5, 9 and 11). In doing so she avoided directly answering students' questions and instead provided opportunities for them to do science. For example, when students asked about the proper placement of a wire, she responded by stating, "I don't know. Look at your schematic drawing," and went on to ask, "What do you think?" She reported that she adapted in this way because "I think that they need to try things out. That's part of the inquiry and doing the science. That was just my way of getting them into the inquiry part."

When Ms. Landers anticipated that the last lesson of the unit might need to be extended beyond the allotted science time, Ms. Landers provided a five-minute warning before she ended students' exploration of electromagnets to provide an explanation. Although, this adaptation seemed to contradict promoting inquiry the rationale she provided acknowledged that some students "were really trying, testing out theories, and listening to each other really well." For those students she wanted them to realize they had five minutes left "so they could finish the inquiry piece" She also explained, "I wanted them to know how much longer they had for it and I didn't want them to have to leave without being able to try out their ideas for making electricity and magnetism work together." It is important to note that the schedule did not allow for Ms. Landers to extend this lesson because students were scheduled for pull-out instruction at which time many students left the classroom. Additionally, the curriculum materials were due to be returned. Given these circumstances, Ms. Landers acted in accordance with the intention of promoting students to engage in inquiry.

Promoting students to figure out how things work. Across six lessons (lessons 4, 9, 10, 11, 12, 13), Ms. Landers adapted seven times in ways that encouraged students to figure out how things work. All of the lessons that Ms. Landers made vision-linked adaptations that promoted students to figure out how thing work, required that students build something or draw on their knowledge of how something worked. Therefore, it appeared that the content of the lessons seemed to allow for adaptations of this nature.

On one occasion, Ms. Landers told students that scientists and electricians used symbols and schematic diagrams and asked students to explain their thoughts about why this might be. In her rationale for this adaptation, she indicated that this helped her assist students with understanding how symbols and diagrams worked in the real world.

On other occasions, she provided an example for students to consider and the followed up with a question. For instance, she referred students to previously recorded data in their science journals and instructed them to discuss what they noticed about the items that stuck to the magnet. Then she demonstrated a magnet chain with a nail and paperclip while posing the questions, "What will happen if I stick something to the paper clip. What's your prediction?" She explained that she made this adaptation because "students had a misconception that everything had to directly touch the magnet for it to stick, so I wanted them to think about that a little bit." In this way, she aimed for students to figure out how a temporary magnet works.

Similarly, when she noticed that students did not grasp the scientific meaning of paths as in possible paths of electricity to a receiver, she asked the class, "When I say path, what do I mean?" Then she provided the example of taking different paths to get to the school's cafeteria. In this instance she aimed to help students understand how series and parallel circuits work to provide electricity paths to a receiver.

Another way that Ms. Landers provided opportunities for students to figure out how things work was through a video. She adapted during planning and decided to show students a video of a crane that used an electromagnet to lift a car in a junkyard. She indicated in her rationale that this would be a good way to help students see how an electromagnet worked. On another occasion while she was teaching, students constructed their own electromagnet, she reminded them to use what they remembered about circuits. In her rationale, she indicated that she wanted students to realize that an electromagnet "got its induced magnetism from a circuit of electricity." In other words, she wanted students to understand how an electromagnet works.

During planning for lesson thirteen, Ms. Landers decided to tell students "exactly how to correctly connect the wires when building an electromagnet so that students realized what was needed and how to make an electromagnet work." However, when she wanted to assist her students to comprehend how to make the electromagnet stronger while teaching this lesson, she adapted by asking a small group "What is your goal?" Then she prompted the group to examine the length of the wire they were using. When students did not demonstrate an understanding for the need to use a longer wire (so that more wire could be wrapped around the rivet making the electromagnet stronger), she directed their attention to another group and suggested that "Maybe you should try the same thing they are doing," at which point a student commented, "Oh, I need to use this other wire."

The content of these lessons seemed to provide logical opportunities for Ms. Landers to adapt in ways that aligned with the feature of her vision that promoted students to figure out how thing work. She appeared to have similar adaptation patterns when she promoted this goal, relying on examples and questions to assist students in developing an understanding of how things work.

A discussion of Ms. Landers's vision-linked adaptations. Ms. Landers' most frequent vision-linked adaptations made while teaching ($N = 16$) and during planning ($N = 4$) promoted students to engage in inquiry ($N = 8$) and figure out how things worked ($N = 7$). The vision-linked adaptations that Ms. Landers made to promote these two features of her vision accounted for about 75% of the vision-linked adaptations that she made and about 38% of the total adaptations she made throughout the implementation of this unit.

The nature of Ms. Landers' vision-linked adaptations and her corresponding rationales seemed to support what has been found in the literature (Brown, 2009) in regards to teachers pedagogical design capacity (discussed in Chapter II). It appeared that Ms. Landers, to some degree, was able to "mobilize existing resources in order to craft instructional contexts" (Brown, 2009, p. 24) that were in accordance with her vision. In other words, she used the curriculum materials and made vision-linked adaptations while teaching and during planning that created opportunities for students to be engaged in inquiry and to figure things out. It also appeared that for Ms. Landers, when she promoted students to figure out how something works she was aiming to develop students' thinking. For example, in each instance she discussed students' thoughts, thinking or understanding. Whereas, when she promoted students to engage in inquiry, she seemed to be promoting students to do something with the materials and therefore it appeared that Ms. Landers associated inquiry as the hands-on, active parts of science. As such, Ms. Landers to some extent promoted the idea that students engage in science with attention to a hands-on, minds-on approach.

Ms. Landers's vision-linked adaptations and target students' learning. Four features of Ms. Landers' vision were represented in the 20 vision-linked adaptations she made (while teaching and during planning). In regards to her target students' learning, Ms. Landers's target students had a 10% average learning gain as measured on the unit pre- and posttest (see Table 24). Comparisons made across Ms. Landers's target students' unit pre- and posttest and learning gains signified several interesting findings (see Table 25).

Table 24

Ms. Landers's Target Students' Average Learning Gain

Vision-linked Adaptations			Mean % Correct for Target Students		
Teaching	**Planning**	**Total**	**Pretest**	**Posttest**	**Gain**
16	4	20	48%	54%	10%

Table 25

Ms. Landers's Target Students' Unit Pre- and Posttest and Learning Gains

Student Achievement Level	Unit Pretest % Correct	Unit Posttest % Correct	% Gained of Possible Percentage Points
Low	39%	50%	17%
Low	54%	61%	14%
Average	57%	48%	-20%
Average	52%	48%	-9%
High	37%	67%	48%
High	46%	50%	8%

First, none of the target students' unit pretest scores indicated an extensive amount of understanding associated with magnetism and electricity prior to the unit (all scored below 70% of the total possible points of 46). Another finding was that the achievement levels of students, as identified by Ms. Landers did not seem to be represented in target students' unit pretest scores. That is, the target students' unit pretest scores indicated considerable variance among the target students. For example:

- both average achieving students' scores (57% and 52%), were similar to a low achieving student (54%) and all three represented the highest unit pretest scores, and
- one high achieving student scored the lowest (37%), while the other high achieving student scored lower (46%) than both of the average achieving students (57% and 52 %).

The unit posttest scores indicated that the highest score of 67% of the total possible points was made by a high achieving target student. Target students' scores on the unit posttest also indicated the following:

- one low achieving student scored (61%) almost as high as a high achieving student (67%),
- one high and one low achieving student, scored the same (50%), and
- both average achieving students, scored the same and the lowest (48%).

The target students' percentages of possible points gained indicated that both of the average achieving students regressed from the unit pre- and posttest (20% and 9%) while the low achieving target students' gains were similar (17% and 14%), and that high achieving target students' gains varied (48% and 8%). The discrepancies that seem to be reflected in Ms. Landers' target students unit pretest scores, and therefore across their unit posttest scores and learning gains, may suggest that Ms. Landers' perception of students' achievement was based on other factors that were not measured in the way that this study measured students' learning. Perhaps for Ms. Landers she viewed students' achievement in light of the extent to which they engage in the particular features of her vision. For example, if Ms. Landers identified students as low, average and high achieving, by the extent to which she perceived students as engaging in the features of her vision, then it is possible that students' unit pretest scores would not be reflective of Ms. Landers perceptions of low, average and high achieving students because it did not measure the extent to which her students take up the features of her vision.

If this was the case (that Ms. Landers' criteria for identifying targets students based on the extent to which she perceived them as taking up features of her vision), then we might still expect to see limited student learning (even when measured as the extent that they take up the features of her vision that the promoted) given that Ms. Landers made vision-linked adaptations in limited ways (infrequently and representing only four of the six features and limited TAT adaptation and rationale types).

In sum, Ms. Landers' target students' science learning as measured in this study was limited as was her practice of making vision-linked adaptations. However, these results should be considered with extreme caution since we do not know the criteria that Ms. Landers' used to identify the target students' achievement level or how her target students might benefit later in their science learning from exposure over time to features represented in her vision-linked adaptations. It is possible that the features that were represented in Ms. Landers' vision-linked adaptations, while were not measurable in terms of students' learning in this study and are not typically measured in the ways we assess students' learning in school, may in the long run have significant impact on students' learning.

Ms. Lawson—Enabling Students to Discover How Things Work

Ms. Lawson viewed teaching as a way to assist students in realizing their individual potential and she believed that her job was to "mold students, make them believe in themselves and help them have goals." She was adamant that if she could get students "to just like school and find what they are good at" that school could help them "realize there are so many possibilities that will help them pursue what they want later in life." For Ms. Lawson, if students appeared to care about school, then that indicated that they also cared about themselves. This seemed to be a critical feature of her vision that was very dependent on students' participation.

Ms. Lawson aimed to help students realize that what they learn in school has connections to the real world and that they will use what they learn now later in life. She also stated that she wanted students to make connections and see that all learning is interconnected and she provided the following example:

> I don't want them to learn how to read per say. I mean because everybody can read. I want them to realize all the things that go with that. Like everybody can read, even if they are two years behind, they are still able to read on a second grade level. It is not necessarily skills that I want them to pick up. I want them to care about school a little bit because that's a reflection of themselves that they care. If they care about school, they obviously care about themselves.

She also indicated that she wanted students to have confidence and the motivation to just try.

Ms. Lawson indicated that one way she was able to enact her vision was by pointing out possibilities for students. For example, she said, "I will tell students that they would make a great doctor and just sort of plant that seed that there is more out there and that they can do it." She further cited that when possible, she integrated her instruction so students can make the connections that all learning is related.

When Ms. Lawson's students seem to connect her teaching to other subject areas or relate what they are learning to real-world applications, then to her, this indicates that students are realizing the benefits of her teaching in accordance with her vision. While

Ms. Lawson was clear about what she looked for in students, she was also specific about the barriers she faced when enacting her vision.

She identified “skills-based” instruction as being particularly problematic “because learning (specific skills) just doesn’t make sense by itself and makes it harder for students to realize how everything is connected.” However, Ms. Lawson seemed to possess strategies for navigating this barrier. For example, after she discussed her concerns with central office personnel about the school system’s required math curriculum, which relies heavily on skills-based instruction; she felt comfortable supplementing it with other activities to help her connect students’ learning to a bigger idea. She also stated that providing small-group instruction allowed her to address specific skills that students needed while also connecting their learning to the instruction she provided during whole group. Ms. Lawson indicated that being able to share the planning responsibilities among her grade level colleagues helped with being able to plan and gather the necessary materials for small-group instruction. She further pointed out that the make up of her class made it “relatively easy for her to enact her vision.” For example, she stated,

> The girls are fabulous. I have never seen a group of fourth grade girls get along so well! They all kind of feed off of one another. I have this one who is really artistic and the other girls who aren’t as artistic, look at her stuff and feed off of that. My boys are the same way. They don’t get crazy with the competition thing. I have good kids who really try.

She also indicated, “they (students) are really easy to get the point across to because their parents for the most part are all really involved.”

Ms. Lawson viewed science as being a model of how all instruction should occur—“Science is fun and I feel like that this is how our whole day should be—doing stuff like science. Science is the only really fun time that we can do all those fun activities and follow-up on things.” She indicated that her approach to science included “placing students in groups for discovery learning” and that she liked “to give students the stuff and let them figure it out.” She stated the goals she held for students as a result of teaching this particular unit included “The discovery aspect—giving them the stuff and having them figure out what to do with it to make it work. I want them to be willing to try and realize that there is not always a right or wrong answer and that there are different ways to solve problems.”

Features of Ms. Lawson’s vision. The content of Ms. Lawson’s vision indicated that she was concerned with students’ dispositions (positive view of school, to care about school, confidence). She also discussed that she wanted students to possess a self-awareness of their strengths and to be persistent. Connected to her aim for students to realize their strengths were also goals she held for students’ learning. Her goals for students’ learning included their awareness of different ways to solve problems and to recognize that all learning is interconnected. Ms. Lawson reported that she is able to help students make connections to the real world by implying that they are suited for a particular career and by integrating her instruction. Ms. Lawson’s preference for science instruction indicated a more open approach to science than Ms. Landers indicated. For example, while Ms. Lawson also privileged an inquiry approach to science where students participated together in small groups with hands-on exploration (like Ms.

Landers) she was not concerned with guiding their inquiries with prompts. It appeared that also associated with her approach to inquiry, was a feature of her vision, which was that students discover how things work. The features of Ms. Lawson's vision are represented in Table 26.

Table 26

Features of Ms. Lawson's Vision

Students experience a positive school/classroom environment
Students possess confidence
Students possess self-awareness of their strengths
Students persist
Students possess multiple ways to solve problems
Students possess an awareness that all learning is interconnected
Students possess an awareness of or application to the real world
Students appreciate or discover how things work

Vision-linked adaptations and rationales. Ms. Lawson most frequently made vision-linked adaptations while teaching ($N = 32$) (see Table 27). Three features of her vision were promoted in about 79% of her vision-linked adaptations (while teaching and during planning). The three features that were promoted included that students discover how things work ($N = 18$), persist ($N = 7$) and possess multiple ways to solve problems ($N = 6$). When Ms. Lawson made vision-linked adaptations while teaching, she most often changed the means by which objectives were met ($N = 30$) which accounted for about 94% of the vision-linked adaptations that she made.

Table 27

Features of Ms. Lawson's Vision Represented in Vision-linked Adaptations Made While Teaching

Feature of Vision Represented in Vision-linked Adaptations Made While Teaching	*TAT Adaptation Types			Total
	II	IV	VI	
Students possess confidence	2			2
Students possess self-awareness of their strengths	2			2
Students persist	6	1		7
Students possess multiple ways to solve problems	4			4
Students possess an awareness that all learning is interconnected	2			2
Students possess an awareness of or application to the real world	1			1
Students appreciate or discover how things work	13		1	14
Total	30	1	1	32

*TAT Adaptation Types: II: Changes the means by which objectives are met; IV: Inserts a mini-lesson; VI: Omits/inserts an activity

Ms. Lawson's rationales indicated that the vision-linked adaptations that she made while teaching and during planning were associated with helping students make connections ($N = 16$) and using knowledge of students or the classroom dynamics to alter instruction ($N = 11$). These rationales accounted for about 69% of her rationales for the vision-linked adaptations that she made (see Table 28).

What follows is a description of how and why Ms. Lawson made vision-linked adaptations in which she promoted students to discover how things work, persist and solve problems.

Table 28

Features of Ms. Lawson's Vision Represented in Thoughtfully Adaptive Teaching Rational Types

Feature of Vision Represented While Teaching and During Planning	*TAT Rationale Types								Total
	B	C	D	E	F	G	I	J	
Students possess confidence				1				1	2
Students possess self-awareness of their strengths			3						3
Students persist	1		1	5					7
Students possess multiple ways to solve problems	2		4						6
Students possess an awareness that all learning is interconnected		1	1						2
Students possess an awareness of or application to the real world							1		1
Students appreciate or discover how things work	2	1	7	5	1	2			18
Total	5	2	16	11	1	2	1	2	39

*TAT Rationale Types: B – Challenge/Elaborate; C – To teach a specific strategy or skill; D – To help students make connections; E – Uses knowledge of students or classroom dynamics to alter instruction; F – Checking students understanding; G – Anticipation of upcoming difficulty; I – To manage time; J – to promote student engagement

Promoting students to discover how things work. Ms. Lawson's vision-linked adaptations most frequently represented the feature of her vision that promoted students to discover how things work (*N* = 18) and were made across seven lessons (lessons 7, 8, 9, 10, 11, 12, 13). For example, during planning for lesson seven, Ms. Lawson adapted by designing a challenge for students who would successfully with managing to get the light bulb to light with two wires. The challenge was to then "figure how to make it work with one wire." She explained that if they could quickly discover how to complete the task with two wires that she wanted them to do the same for one wire. While teaching this lesson, Ms. Lawson monitored groups of students and asked students to explain what they figured out about how to get the light bulb to work. When they responded with general answers that indicated students knew it had to be connected to a battery, she acknowledged their responses and continued to question them about the specific location where the wires had to be placed on the light bulb and battery before the light bulb would work. Ms. Lawson indicated that she adapted this way because she realized that “students had figured it out” and believed that if she prompted them in this way and had them explain it to her that students would remember “it had to work this way.”

Similarly, in another lesson, Ms. Lawson adapted when students were building circuits for motors. After she assisted them to understand where to properly place wires so that the motors in the circuit would run and made sure students knew why the wires needed to be placed in a position that would provide a source of electricity to the motor, she prompted students to try different ways to direct power to the motor. In her rationale for this adaptation she explained, “I wanted students to think about and be able to explain how the circuit was working. I knew they would get it working, but did they really figure out how it was working? If they figured out how it was working, then I thought the could probably direct power in different ways.”

In another adaptation, Ms. Lawson aimed to help students discover how to increase the brightness of a light in their constructed circuit. Before she made the adaptation, students complained that their bulb would not glow brightly. She asked the group of students “So what do you think you need?” As students replied listing different materials, she gave the group of students all of the tools they requested (when all they really needed was a battery) and then had them rebuild the circuit. She provided the rationale, “I wanted them to figure out how to fix it and then have them try it out.”

While teaching the last lesson, Ms. Lawrence traveled from group to group and asked each group different questions about what steps they were taking to build an electromagnet. Her rationale captured her ability not only to deal with the complexities of teaching but also her propensity to be reflective, which demonstrated just how attuned she was to what all of her students were doing and where they were experiencing difficulty. She explained,

> Well, this group was having trouble building their circuit because their rivet was still out in left field and not connected to anything. So, they were getting circuit questions. Another group wasn’t connecting the rivet the right way so I was trying to get them to look at how they were connecting the rivet. And then I noticed that another group said that ‘maybe the yellow wire needs to be connected to battery’ so it just depended on where they were in the process of building the electromagnet as to what question I asked them. But I asked them so that it would help them figure out how to make the electromagnet work.

All of these adaptations described here reflected the typical ways that Ms. Lawson promoted students to discover or figure out how something works. This was the feature of her vision that was represented most frequently in the vision-linked adaptations she made ($N = 18$). For Ms. Lawson, this meant that she often used questions and then had students try out the solutions they suggested verbally by working directly with the materials.

Promoting students to persist. On seven occasions across four lessons (1, 4, 7, 13), Ms. Lawson made vision-linked adaptations that promoted students to persist. When she adapted this way, her rationales indicated that she used knowledge of students or classroom dynamics to alter instruction

For example, during lesson one Ms. Lawson provided students the choice between working alone or as part of a group. She indicated in her rationale that there were some students who needed to be with other students so that they would be motivated to explore while others would rather work alone and did not need the sort of encouragement that her more timid students needed. In describing her rationale for this adaptation, she further described particular students that she was thinking about as she made the adaptation and highlighted both the benefits and disadvantages of working alone and as a part of the group for each student she described.

In another lesson, Ms. Lawson provided students with the necessary materials to build a model of ‘repelling doughnut magnets’ after they viewed a video of it. This is accomplished by placing a pencil through the hole of several doughnut magnets with the like poles facing each other so that the magnets will repel, providing the illusion that the magnets were floating. When students demonstrated difficulty, she adapted by encouraging students to try different placements of the magnets while also letting them know to “keep working at it.” She explained in her rationale that she sensed some students were getting frustrated and that she wanted them to “keep trying until they got it.”

Other adaptations she made that promoted students to persist were very similar. That is, she changed how she approached the lesson and provided a rationale that indicated her decision to do so was rooted in her aim to help or encourage students to persist through the activity. When compared to TAT adaptation types, the vision-linked adaptations made of this nature, signified that she changed the means by which the objectives were met. Just like the vision-linked adaptations she made that promoted students to figure our how something worked, she often used questions and then had students try out solutions by working directly with the materials. However, there was an element of encouragement present in the rationales that she offered for these kinds of vision-linked adaptations. Her rationales also indicated that she used her knowledge of students or classroom dynamics to alter instruction.

Promoting students to possess multiple ways to solve problems. For five lessons (2, 7, 8, 11, 12) Ms. Lawson made vision-linked adaptations to help students solve problems by encouraging them to approach assigned tasks with multiple approaches. For example during lesson two, Ms. Lawson had students explore the room for magnetic items and she situated the lesson by explaining that students were going to be detectives where they were going to have to find items in the room that were magnetic and figure out why some items were magnetic and others were not (materials must contain iron or steel to be magnetic). Before she allowed students to begin, she asked "Now, what are some ways that we might go about doing this?" She also encouraged students to "be creative" and think about what they already knew about items that were magnetic. Further, throughout the lesson, she continued to encourage students to think of ways that they could solve the mystery of what magnetic items were made of. Her rationale indicated that she wanted them to use any approach they wanted but for it to make sense. In this way, she promoted that students engage in problem-solving and gave them opportunities to practice approaching the problem (What are magnetic items made of?) in a variety of ways.

Similarly, for another lesson, she situated the lesson by telling students that they were going to be electricians and that they had to solve the problem of constructing a circuit with a switch that worked. She told students that she did not care how they approached the problem and what materials they used. Her rationale was that she adapted in this way because she “wanted them to approach the problem in any way they thought they needed to.”

Ms. Lawson’s approach to promoting students’ to possess multiple ways to solve problems was also evident when she told students that she had a problem with her car and that she knew an electromagnet could pick it up and but that she was not aware of a way to build an electromagnet so students’ jobs were to work together to build an electromagnet to help her solve the problem of moving her car. She explained that making this about a real-world problem would help encourage students to look at solving problems. When Ms. Lawson promoted this feature of her vision; she mostly situated the lesson around a problem that needed to be solved and then encouraged and allowed space for students to think about how to try to solve the problem in varied ways.

A discussion on Ms. Lawson’s vision-linked adaptations. Ms. Lawson’s most frequent vision-linked adaptations made while teaching ($N = 32$) and during planning ($N = 7$) promoted students to discover how things work ($N = 18$), persist ($N = 7$) and possess multiple ways to solve problems ($N = 6$). Collectively, these vision-linked adaptations made to promote these features of Ms. Lawson’s vision accounted for about 79% of her vision-linked adaptations and about 38% of the total adaptations that she made throughout the unit implementation. The nature of Ms. Lawson's vision-linked adaptations and her corresponding rationales seemed to represent what Brown (2009) referred to as pedagogical design or the teacher's ability to use resources to provide learning opportunities for students and that to an extent, she considered the needs of her students as she crafted those instructional situations. Further, it appeared that Ms. Lawson's vision-linked adaptations that previously described were all related. That is, while she promoted students to discover how things work, she also encouraged them to persist and approach multiple ways to solve problems. It seemed that these three particular features of her vision did not necessarily stand alone when she made vision-linked adaptations. For example, when she encouraged students to discover how things work, to some extent she also encouraged them to persist and that embedded in these adaptations was also, to some extent, encouragement to approach the task in multiple ways.

Ms. Lawson's vision-linked adaptations and target students' learning. Seven features of Ms. Lawson's vision were represented in the 39 vision-linked adaptations she made (while teaching and during planning). In regards to her target students' learning, Ms. Lawson's target students' had a 14% average learning gain as measured on the unit pre- and posttest (see Table 29). Comparisons made across Ms. Lawson's target students' unit pre- and posttest and learning gains indicated the following findings (see Table 30).

First, none of the target students' unit pretest scores indicated an extensive amount of understanding associated with magnetism and electricity prior to the unit. It also appears that the achievement levels are to some extent represented in target students' unit pretest scores. That is, the target students' achievement level as identified by the teacher is supported by the percent correct on the unit pretest with low achieving students scoring the least amount correct and high achieving students scoring the highest percent correct.

Table 29

Ms. Lawson's Target Students' Average Learning Gains

Vision-linked Adaptations			Mean % Correct for Target Students		
Teaching	**Planning**	**Total**	**Pretest**	**Posttest**	**Gain**
37	2	39	48%	65%	14%

Table 30

Ms. Lawson's Target Students' Unit Pre- and Posttest and Learning Gains

Student Achievement Level	Unit Pretest % of Possible Points	Unit Posttest % of Possible Points	% Gained of Possible Points
Low	43%	61%	31%
Low	46%	52%	12%
Average	48%	48%	0%
Average	50%	54%	9%
High	54%	63%	19%

The unit posttest scores indicated that the highest score of 63% correct was made by a high achieving target student. Target students' scores on the unit posttest also indicated the following:

- one low achieving student scored (61% correct) almost as high as a high achieving student (63% correct),
- one average achieving student scored (54% correct) similarly to one low achieving student (52% correct), and
- one average achieving student maintained a score of 48% correct.

The percentage of possible points gained indicated that a low achieving student gained a higher percentage of points possible from the unit pre- and posttest (31% of the possible points). Finally, none of the target students' scores on the unit posttest indicated a substantial understanding of magnetism and electricity as measured by the unit posttest, yet all but one student did make gains.

It appears that Ms. Lawson's low and high achieving students' learning, as measured by the unit pre- and posttest, benefitted the most from her instruction. They made the most gains. Further, in Ms. Lawson's vision-linked adaptations she most frequently adapted in ways that aligned with promoting students to figure out how things work by changing the means by which objectives were met (TAT adaptations type II) and often did so to help students make connections (TAT rationale type D) while also using knowledge of students or classroom dynamics to alter instruction (TAT rationale E), suggesting that Ms. Lawson, when making adaptations, mostly considered her low and high achieving students. Perhaps these findings also indicate that Ms. Lawson needed to adapt in ways that she did not. For example, if she adapted more frequently by modifying the lesson objectives, while using knowledge of her students, then maybe target students' unit posttest scores would indicate higher learning gains.

To summarize, Ms. Lawson's target students' science learning as measured in this study signified learning gains and she to some extent adapted in ways that aligned with her vision. As was the case with Ms. Landers, these results should be considered cautiously since the way in which students' learning was measured in this study was limited to a 15-item test. Further, like Ms. Landers' case, it is also possible that the features of Ms. Lawson's vision that were represented in her vision-linked adaptations, may significantly impact students' learning over a longer period of time.

Ms. Rose—Shaping Contributing Members of the Science Community

Ms. Rose became a teacher because as she stated, "In my life I had lots of important people. As an adult when I look back I think about the way they impacted me and changed my life. And I want to be able to impact someone positively in that way." She indicated that for her teaching is about helping students realize their strengths and potential and building on those strengths so that students "can later become a functioning and contributing member of society." She also stated that she can have "her students think about things that maybe as a child they weren't already thinking about," and that "teaching is my opportunity to extend what they are able to do alone."

What Ms. Rose aims to accomplish as a teacher is directly related to why she became a teacher. For example, she stated,

> I want my kids to be able to be a member of society—a contributing member. I want them to enjoy learning and that whatever I give them to be concrete enough that they can take it and use it later to find out whatever it is they want to be—you know no matter what their job is or what they choose to do, but I want them to be able to do that the best way they can.

When asked to further explain what she wants her students to become, she replied,

> Whatever it is they want to be. If they want to be a doctor, I want them to be able to do that and to have the drive and the tools necessary to be a doctor. If they flip burgers at McDonald's, I don't care as long as it is their personal choice. I want them to know enough about the world and about life to be able to make decisions about what they want their role to be.

She summed up her big goals that she was trying to accomplish as promoting her students to "love learning and to be able to use their learning in everyday, real-world situations."

Ms. Rose reported that she enacts her vision by approaching learning from a stance of inquiry. She added that her approach to inquiry meant that she avoided telling students how to do something. Rather, she preferred to give students the materials they need and have them work together in groups to complete the task, exploration or investigation. She also provided a clear picture of what she looks for in students to indicate that they understand her vision. Referring to the "ah ha moment" as "the number one clue that students are figuring out things," she reported that kids will "scream out, 'oh! I get it now!'" and further stated, "I mean in here if you get it, we are all excited."

For Ms. Rose, inquiry also means that conversations in her classroom are student centered which she pointed out "lends a hand to being cooperative in society." She stated that "Students are talking to each other and they are working together." Ms. Rose further commented that "part of my vision is them working together" and that she sets up situations where students have to rely on one another and therefore provides as many opportunities as possible for students to work together and to learn from each other.

Ms. Rose specified that at the beginning of the year, her students needed explicit and clear expectations about what “working together looks like.” Therefore, she gave “them lots and lots of pointers.” She also provided students with specific roles or jobs in the group and frequently changed the roles so that all students would learn how to take on the different roles. Ms. Rose stated, “at this point in the year, I can say we are all going to work together and they do it because they know the expectations.” This indicated that at the time of this study, the third nine weeks of the school year, that she believed that she was able to enact a major component of her vision. That is, she was able to have students work together which was also embedded in her approach to inquiry. She further pointed out that when she sees students working together and being cooperative group members, without having to tell them to do it, that she knows they understand this aspect of her vision. Offering a specific example of when she sees students doing this she stated, “A lot of the time, I find during writing that I don’t even say ‘you can get up and help each other’ and they just do and that’s how I am sure that they know we are suppose to help each other with whatever our goal happens to be.”

Given Ms. Rose’s interest in promoting students to cooperatively work together it was not surprising that she also valued the personal connections that she has with her students. In fact, she was adamant that “nothing stands in my way of that (connecting with students) and if it did I wouldn’t let it.” She suggested that because she neither had children or a family of her own that she had time to do the things she deemed necessary to facilitate connections with her students.

Ms. Rose seemed focused and committed to her vision but she also identified barriers to enacting her vision. She indicated that trying to implement, at the same time, new teaching approaches to literacy and math required by her district coupled with state accountability measures, made her feel “restricted about what she could choose to do with her students.” She specifically cited that within the system-promoted approach to literacy that it was a “very strict regimented system” where specific time limits were placed within the scheduled blocks of literacy instruction. However, she seemed to possess strategies to navigate through the restrictions stating that “I try to get as much of me in those little activities” and offered the example of being able to at least choose the topic during literacy instruction, which she pointed out was usually a science topic selected for the listening and research center. Interestingly, Ms. Rose also pointed out that if she did not do these sorts of twists, that she “would hate” her job.

Ms. Rose indicated that she wanted students “to know how to function in a world where you have to work together” and specifically “work together cooperatively.” She also indicated that she wanted her students to “learn how to discover things for themselves and not always have to be told what to do.”

When further prompted about what she aimed for students to learn as a result of teaching the science unit, she stated, “the North Carolina Standard Course of Study (NCSCOS) because by law that is my job.” Drawing from the NCSCOS, she identified that she wanted students to learn that electricity is “used to make some sort of product” and “travels in a circuit.” She also wanted students to learn about “conductors and insulators.” Related to the real world, Ms. Rose wanted students to associate that “some people have jobs where they have to make sure electricity functions" and that "electricity is how you get your lights and water pump." In terms of magnetism, her goals for students' science learning were also associated with the NCSCOS. She aimed to promote students' understanding of magnetism. Again, pointing out real world connections, she wanted students to learn how electricity and magnetism were used together in the real world.

Features of Ms. Rose's vision. Ms. Rose's responses indicated the features of her vision included that students possess knowledge of themselves and independence. She also wanted to provide a positive classroom environment that would help students develop an enjoyment or love of learning. Of particular significance was that Ms. Rose was acutely aware of what she was expected to teach (NCSCOS), what she wanted students to learn and merged the two in the goals she held for students' learning. As part of the goals she held for students' learning she included that students make connections to the real world. Her notions of inquiry were similar to Ms. Landers' and Ms. Lawson's in that she believed that students should work together and figure things out. However, she articulated specific strategies that she used to teach her students how to work together. While Ms. Landers' and Ms. Lawson's image of inquiry represented particular aspects of inquiry (exploration and figuring things out), Ms. Rose's image of inquiry seemed broader by also including components of communication along with collaborative and cooperative work as part of doing inquiry. For example she stated, "I teach with inquiry-based learning and I think that you can't do that without having the conversations in your classroom being student-centered and kids talking to each other and working together." Ms. Rose's stance towards inquiry seemed to signal a meaningful way for her to enact her vision (see Table 31).

Table 31

Features of Ms. Rose's Vision

Students possess knowledge of self
Students possess independence
Students experience a positive classroom environment
Students possess an awareness of or application to the real world
Students engage in inquiry
Students learn science outlined in the North Carolina Standard Course of Study
Students work collaboratively

Vision-linked adaptations. Ms. Rose most frequently made vision-linked adaptations while teaching (*N* = 52) (see Table 32). Four features of her vision were promoted in about 81% of the vision-linked adaptations she made while teaching. The four features that were promoted most often included that students (a) learn science outlined in the NCSOS (*N* = 18), (b) experience a positive classroom environment (*N* = 9), (c) engage in inquiry (*N* = 8), and (d) possess an awareness of or application to the real world (*N* = 7). When Ms. Rose made vision-linked adaptations, she most often changed the means by which the objectives were met (*N* = 22) and provided an example, analogy, or metaphor (*N* = 10) that together accounted for about 62% of her vision-linked adaptations.

Table 32

Features of Ms. Rose's Vision Represented in Vision-linked Adaptations Made While Teaching

Feature of Vision Represented in Vision-linked Adaptations Made While Teaching	*TAT Adaptation Types							Total
	I	II	III	IV	V	VI	VII	
Students possess knowledge of self		3	1					4
Students possess independence		2				1		3
Students experience a positive classroom environment		5			1	3		9
Students possess an awareness of or application to the real world		1	4		2			7
Students engage in inquiry		3	2		2		1	8
Students learn science outlined in the North Carolina Standard Course of Study	1	6	3	4	1	2	1	18
Students work collaboratively		2				1		3
Total	1	22	10	4	6	7	2	52

*TAT Adaptation Types: I – Modifies the lesson objective; II – Changes the means by which objectives are met; III – Invents examples, analogy or metaphor; IV – Inserts a mini-lesson; V – Suggests a different perspective to students; VI – Omits/inserts an activity; VII – Changes planned order of instruction

Ms. Rose's rationales indicated that the vision-linked adaptations that she made while teaching and during planning were mostly associated with helping students make connections and using knowledge of students or the classroom dynamics to alter instruction, which together accounted for about 48% of her rationales (see Table 33).

What follows is a description of how and why Ms. Rose made vision-linked adaptations in which she promoted students to: learn science outlined in the NCSCOS, experience a positive classroom environment, engage in inquiry, and possess an awareness of or application to the real world.

Table 33

Features of Ms. Rose's Vision Represented in Thoughtfully Adaptive Teaching Rational Types

Feature of Vision Represented While Teaching and During Planning	*TAT Rational Types								Total
	B	C	D	E	F	G	I	J	
Students possess knowledge of self	2					2			4
Students possess independence			3						3
Students experience a positive classroom environment		1		5		2		3	11
Students possess an awareness of or application to the real world		1	6		1				8
Students engage in inquiry	2	1	7				2		12
Students learn science outlined in the North Carolina Standard Course of Study	4		1	6	4	2	2		19
Students work collaboratively				1				2	3
Total	8	3	17	12	5	6	4	5	60

*TAT Rationale Types: B – Challenge/Elaborate; C – To teach a specific strategy or skill; D – To help students make connections; E – Uses knowledge of students or classroom dynamics to alter instruction; F – Checking students understanding; G – Anticipation of upcoming difficulty; I – To manage time; J – to promote student engagement

Promoting students to learn science outlined in the North Carolina Standard Course of Study. Across 12 of the 13 lessons, Ms. Rose adapted in ways that promoted students to learn science outlined in the NCSCOS. Accordingly, the rationales that she provided for these adaptations indicated certain aspects of students' understanding related to magnetism and electricity.

The NCSCOS Science objective 3.01 states that students "observe and investigate the pull of magnets on all materials made of iron and the pushes or pulls on other magnets." While teaching, Ms. Rose noticed that students did not grasp the concept that magnets do not stick to all metals. She instructed students to discuss the commonalities among the items that magnets stuck to. She indicated that she wanted to figure out where students were getting confused so that she could "clear up the misconception that magnets stick to all metals and to help them understand that magnets only stick to objects with iron." In this way she changed the means by which the objectives were met.

On the occasions that Ms. Rose made adaptations tied to the NCSCOS objective, "design and test an electric circuit as a closed pathway including an energy source, energy conductor, and an energy receiver," she narrowed her instruction by omitting an activity suggested in the curriculum materials so that she could focus on students making a circuit and discovering "what makes it work." In another adaptation, she demonstrated an open and closed circuit and provided the metaphor that a circuit is a circle because it is closed. Ms. Rose also told students, "If the wires of a circuit never touch, a circle is not created. And because it is open it won't work. A closed circuit is a circle and works." Her rationale indicated that she noticed students were having a hard time understanding the difference between open and closed circuits and so she decided "to stop the inquiry and tell them." She further stated, "I was like alright, they've done their thing and they still can't put this into their own words." In this way, she promoted students to learn science outlined by the NCSCOS as well as concepts beyond (open circuit) the NCSCOS. In another instance, Ms. Rose sensed that students did not understand the different types of circuits (parallel and series) even though they were investigating them (NCSCOS objective 3.07). She provided a visual for students that incorporated pictures and words “so that students understood the different types of circuits.” For example, she drew an example of both circuits and labeled them. In doing so she highlighted that in parallel circuits, electricity has several paths that it can travel by circling all the paths the drawing provided.

In another lesson, Ms. Rose decided to “review students’ learning about electromagnets by allowing them to build an electromagnet for a second time.” She stated, “I don’t think they understood that breaking the circuit will stop the magnetic field and that the rivet can’t be a magnet anymore.” In this way, she promoted that students learn the NCSCOS objective, which states, “observe and investigate the ability of electric circuits to produce light, heat, sound, and magnetic effects.”

When Ms. Rose adapted in ways that promoted students to learn science outlined in the NCSCOS, she always related her rationale to students’ understanding and stated that she wanted to encourage the development of students’ conceptual knowledge or clear up misconceptions that students held.

Promoting a positive classroom environment. On nine occasions while teaching across six lessons (lessons 1, 2, 8, 10, 11, 12), Ms. Rose made adaptations to promote a positive classroom environment. When she adapted in this way, she provided rationales related to students’ affective dispositions.

For example, when students, without being prompted recognized the essential question “What do we know about magnetism?” Ms. Rose allowed for an unplanned whole class conversation to evolve. She indicated that she made this adaptation because “I wasn’t going to just stop that conversation from happening. I knew that they were getting excited and I want my kids to be excited about learning." Similarly in another lesson, she noticed that students' faces indicated that they made a connection between parallel circuits and parallel lines and again, she allowed them to openly discuss the connections they made. Further, when a student made a connection to magnetism, Ms. Rose praised the student for his connection and had the student explain his thinking to the rest of the class. She stated that she adapted in this way because she "thought that it was important to validate him."

While teaching lesson 10, Ms. Rose aimed for students to create circuits. When a student suggested to Ms. Rose that a battery was not working properly, she adapted by providing a new battery for the student and followed up with a brief mini-lesson in which she assisted him with creating the circuit. She indicated that she made this adaptation because "He was feeling defeated." When asked about whether or not she would have adapted in this same manner with all students, she acknowledged that she would not have given a higher achieving student as much attention. She offered that "with a student like Josephine (higher achiever), I would have just quickly asked her some questions and gotten her back on track and moved on but someone like David (lower achiever) I have to sit down with him. He's capable but when he starts feeling defeated he will shut down."

While teaching this same lesson, another lower achieving student stated, "I can't get this thing to work." Ms. Rose adapted by correcting him for stating 'I can't.' She told the student, "We don't do that in this classroom." She explained that she responded to him in this way because, "Some kids who are lower performing think they can't because they've been told they can't or their test scores show that they can't or they just can't in other subjects. I think it's the whole expectation thing and the self-fulfilling prophecy." In both of these instances Ms. Rose promoted a positive classroom environment where are all students could feel accomplished, rather than defeated and believe in their ability rather than their inability.

When Ms. Rose adapted in ways that promoted a positive classroom environment, most of the adaptations occurred while teaching and she indicated in all instances that she aimed to shape a particular aspect of students' affective dispositions (excited, validated, accomplished) which indicated that she possessed a clear sense of her students' emotional needs and responded accordingly.

Promoting students to engage in inquiry. Across eight lessons Ms. Rose made 12 adaptations to promote students' engagement in inquiry (lessons 1, 5, 6, 7, 8, 10, 11, 13). When Ms. Rose indicated that she wanted students to "play around" with an idea or investigation, this playing around, according to Ms. Rose was an adaptation that promoted students to engage in inquiry. For example, while teaching lesson one, Ms. Rose pointed out to the entire class that a portion of a student's keychain was sticking to a desk while another portion was not and then posed the question "Why is that?" She stated that she "was hoping that somebody would play around and figure that out. I wanted him to think about it so I told everyone else and let them try that out."

For lesson five, she told students to "play around with breaking the magnetic force to figure out a good way to do this that we can all agree on." After students worked in their groups, she led a whole group discussion about how to establish standard procedures for such an investigation. Ms. Rose indicated that she wanted the data collected by students within their groups to be “compared across the class” and then explicitly connected this adaptation to her vision. She said,

> I think it has a lot to do with my vision. Last time this (referring to the curriculum materials) was my guide and I used it thinking that I couldn’t go wrong. But this time I want it to be more inquiry based and I want them (students) to get it. I feel like this time I’m doing more of what I want to do than what I did last time.

Similarly, Ms. Rose decided to have students build series and parallel circuits before she provided them with the academic terms of series and parallel circuits. Ms. Rose viewed this adaptation as “making the lesson more inquiry based than the kit suggested.” She further pointed out that she made this adaptation “because it was my personal preference and part of my vision. I feel that the kids are more likely to understand the name and the definitions that I give them if they have something concrete to base it on and connect it to.”

In another instance an adaptation that she made in one lesson led to a planned adaptation in the next. While teaching lesson 10, a pair of students demonstrated success with building a circuit with two wires. In response, she challenged them to build a circuit with only one wire. Because she “felt like everybody should get to do that (challenge task) and not just because they figured it out first,” as other pairs of students accomplished the original task (using two wires), she adapted by posing the same challenge.

At the conclusion of this lesson, some students were still working on the original task with others aimed to complete the challenge task. When Ms. Rose announced that it was time to conclude the lesson, her students reacted with pleas to allow them to continue to work. Rather than allowing the lesson to progress over the allotted time, Ms. Rose decided to end the lesson and instead, promised students that in lesson 11 she would allow time for them to continue their work. In this way, Ms. Rose capitalized on the opportunity that emerged from an adaptation made while teaching, which ultimately resulted in a planned adaptation where she allowed students to "play around with the components of the circuit" while "they formed the necessary knowledge about how to get the light bulb to light with two wires and then with only one."

Through adaptations made like the ones described above, Ms. Rose appeared committed to the feature of her vision that promoted students to engage in inquiry. Further, when she made adaptations that promoted inquiry, Ms. Rose also indicated that she believed students would be better able to "get it" or "understand" what she was trying to accomplish in lessons. It appeared that Ms. Rose's inquiry approach to instruction, which is part of her vision, is also rooted in her beliefs about how students learn best.

Promoting students to possess an awareness of or application to the real world. Ms. Rose made seven adaptations across six lessons (1, 2, 6, 8, 11, 13) with the intentions to promote students' connections to the real world. When she made adaptations for this reason, she generally provided a rationale that demonstrated her belief that connecting instruction to the real world helped students learn and understand. For example, she stated "Anytime I see a connection that might make it make sense to them (students), or make it real, or make them (students) understand why this is important in the real world, I try to point that out."

At the beginning of the unit implementation, Ms. Rose was more direct, or less reliant on students' responses or cues when she connected her instruction to the real world. For instance, while teaching lesson two she adapted by asking students "Are we learning something that will affect everybody's life?" Four lessons later in lesson six, she recognized students' comments about needing electricity to survive as their way of making real world connections and responded by posing the question, "Do we really need it?" Her rationale for this adaption was, "I thought it would be an interesting point to make that you can, in fact, live without electricity. It (electricity) just makes life a lot easier." Then, while teaching lesson eight, a student asked, "How does the remote of a remote control car make it go?" She again recognized that a student was connecting to the real world and responded by posing his question for the entire class. Ms. Rose also indicated that "This was not something I expected them to connect but I thought it was an excellent question. He was taking what he was learning and trying to apply it to his real world and so inside I was like 'yeah'!" Later in lesson eleven, a student asked about the positive and negative ends of a battery needing to be properly aligned in a toy so that it would work. Ms. Rose responded again by posing the question for the entire class, "Why doesn't a toy work when the negative and positive ends of the battery aren't lined up right?" She further detailed for students how their electric toys had circuits inside of them. Ms. Rose believed that students' questions were the most important part of a lesson "because those are the questions that they have based on what they know and so I feel like when I'm answering those questions I need to really make it make sense to them. I think the best way to do that is through a real world connection. They need to see how this connects to their real life."

While teaching the initial lessons of this science unit, Ms. Rose adapted in accordance with the feature of her vision that promoted students' connections to the real world. As the unit progressed, some of Ms. Rose's students commented and posed questions that demonstrated their connections to the real world. Further, when Ms. Rose recognized that students made those connections, she exercised these connections as opportunities to further promote this feature of her vision.

A discussion of Ms. Rose's vision-linked adaptations. Ms. Rose's most frequent vision-linked adaptations made while teaching (*N* = 52) and during planning (*N* = 8) promoted students to learn science concepts outlined in the NCSCOS (*N* = 19), experience a positive classroom environment (*N* = 11), engage in inquiry, (*N* = 12), and posses an awareness of or application to the real world (*N* = 8). Collectively, the vision-linked adaptations made to promote these features of Ms. Rose's vision accounted for about 83% of the vision-linked adaptations that she made and about 78% of the total adaptations she made throughout the implementation of this unit. The nature of her vision-linked adaptations seemed to indicate she had a keen sense of her vision and how to enact it. She further demonstrated through the rationales that she provided for her vision-linked adaptations that she had a clear perception of what her students' learning and affective dispositions needs were. It also appeared that Ms. Rose believed that promoting inquiry and real-world connections assisted her with helping students develop their positive affective dispositions and their science learning.

All the features of Ms. Rose's vision were represented in the vision-linked adaptations she made while teaching and during planning. Her vision-linked adaptations were also representative of all seven TAT adaptation types and eight of the ten TAT rationale types, which indicated that she adapted her instruction in a variety of ways for a variety of reasons or is able to apply a variety of strategies to assist students in ways that are rooted in her vision. For her vision-linked adaptations, she never provided a rationale that indicated she adapted because the lesson objective was not met (TAT Rationale Type A) or to manage student behavior (TAT Rationale Type H).

Ms. Rose's vision-linked adaptations and target students' learning. Ms. Rose made 60 vision-linked adaptations and as discussed above, all of the features of her vision were represented in her vision-linked adaptations. In regards to her target students' learning, Ms. Rose's target students' had a 41% average learning gain as measured on the unit pre- and posttest (see Table 34). Comparisons made across Ms. Rose's target students' unit pre- and posttest and learning gains indicated the following findings (see Table 35).

Table 34

Ms. Rose's Target Students' Average Learning Gain

Vision-linked Adaptations			**Mean % Correct for Target Students**		
Teaching	**Planning**	**Total**	**Pretest**	**Posttest**	**Gain**
52	8	60	52%	72%	41%

Table 35

Ms. Rose's Target Students' Unit Pre- and Posttest and Learning Gains

Student Achievement Level	Unit Pretest % Correct	Unit Posttest % Correct	% Gained of Possible Percentage Points
Low	46%	57%	20%
Low	57%	78%	50%
Average	48%	85%	71%
Average	54%	67%	29%
High	54%	76%	57%
High	57%	65%	20%

While there was variance among the target students' unit pretest scores, there was some indication that none of the target students' held an extensive amount of understanding associated with magnetism and electricity prior to the unit implementation (all scored below 70%). It also appeared that there was variance among the achievement levels represented in target students' unit pretest scores. That is, the target students' achievement level as identified by Ms. Rose, did not seem to be supported by the data. For example: a low achieving student scored (46%) similar to an average achieving student (48%), a low achieving student scored (57%) the same as a high achieving student (57%) on the unit pretest, and an average achieving student scored (54%) the same as a high achieving student (54%) and similar to the other high achieving student (57%).

The unit posttest scores indicated that an average achieving student made the highest score of 85%. Target students' scores on the unit posttest also indicated the following: one low achieving student scored (78% correct) slightly higher than a high achieving student (76% correct) and one average achieving student scored (67% correct) similarly to one high achieving student (65% correct).

The percentage of possible points gained indicated that an average achieving student gained a higher percentage of points possible from the unit pre- to posttest (71% of the possible points) and this was the same student who scored the highest on the posttest. Finally, all six target students' scores on the unit posttest indicated gains while three students' scores indicated a substantial understanding (of at least 70% of the total possible points) of magnetism and electricity as measured by the unit posttest.

It appears that all of Ms. Rose's target students' learning, as measured by the unit pre- and posttest, benefitted to some extent from her instruction. All of the target students made gains with no discernible pattern in which target students may have benefitted more or less. Ms. Rose made more vision-linked adaptations in which she frequently promoted that students learn science outlined in the NCSCOS. Given the alignment of the FOSS unit (discussed in Chapter I) with the NCSCOS, and Ms. Rose's frequency of adapting in ways that promoted students' learning of the science content outlined in the NCSCOS, it is not surprising that all of Ms. Rose's students experienced positive learning gains. In other words, the vision-linked adaptations she made promoted an aspect of students' learning that could be directly measured by the unit posttest in this study. Further, Ms. Rose's vision-linked adaptations represented all seven TAT adaptation types, indicating that perhaps when making vision-linked adaptations in a variety of ways that students' learning may benefit. That is vision-linked adaptations that are enacted in varied ways may provide the scaffolding that students needed to experience positive learning outcomes. Given that Ms. Rose never provided a rationale that indicated she adapted because the objectives were not met yet three of her target students' unit posttest scores indicated a shallow understanding of magnetism and electricity (score of less than 70%), it is possible that she was unaware of any objectives that were not met and therefore did not deem it appropriate to adapt for this reason. Perhaps there were unmet objectives in lessons and students' science learning could have benefitted from adaptations if Ms. Rose realized this.

In summary, Ms. Rose's target students' science learning as measured in this study indicated positive outcomes and Ms. Rose also frequently adapted in accordance with her vision across a variety of TAT Adaptation and Rationale Types. Like the other teachers in this study, Ms. Rose's vision was also characterized with features that may benefit students' learning in ways that were not measured in this study. At the conclusion of this section, when all four teachers' vision-linked adaptations and students' learning are compared, the nature of the relationship between each teacher's vision-linked adaptations and their students' learning will be discussed more thoroughly.

Ms. Winn—Challenging Students to Become Problem-solvers

Ms. Winn drew on her experiences as a student to describe why she became a teacher. She recalled being a good student who was smart and quiet. She also suggested that because she was not challenged in school that she spent a lot of time being bored. As she has grown older she realized this and now tries to challenge her own students. She further indicated that she aims to be a positive role model and that being a teacher allows her to promote equity among her students so that “they all have a chance to make something of themselves.” Describing herself as “mom, nurse, babysitter and teacher” she explained, “I try to be for students, what they need me to be so they can be successful in life.” She defined being successful in life as “giving back to and participating in society” and further explained that “Not everybody can be a doctor but everybody should have the opportunity to become one if they want to. I want to be able to provide what they need to be able to do whatever it is they want to do whenever they are finished with school.”

Ms. Winn also indicated that she wanted students to be able to apply their learning to the real world, become problem-solvers and possess confidence and independence. She viewed that teaching students to solve problems and teaching them how to use available resources to assist them with solving problems was important because “that’s what is needed in life” and that she wanted her students “to have enough knowledge to be able to at least know how to help themselves.”

Ms. Winn reported that she attempts “to enact her vision by giving students as many real life situations as possible” but indicated “that unfortunately most of the time I have to teach them just the skill until they are ready to apply it to a situation” and therefore, she works “each day to build the foundation in any subject so that they (students) can take what they have learned and apply it to a task.” She provided an example of how she does this when she begins teaching about division. After she teaches students the process of how to divide she provides the real-world task of planning a party where students must apply their knowledge of division.

Ms. Winn appeared to possess practical strategies for gauging whether or not students were benefitting from her enactment of her vision. She prefers to draw on the conversations she has with students to get them to explain how they know something or to discuss with them how they plan to go about solving the assigned problem or task. However, she acknowledged that this was a lot more difficult to do than reviewing their written assignments since she requires students to show their work. She also looks for students to use all of the resources that are available to them to complete assignments or accomplish tasks as well as expecting students to persist "until they are satisfied with the results they get."

Even though she was fairly clear about what she looks for in students, she also identified particular challenges she experiences while trying to enact her vision. She associated having a "very needy class" as making it difficult for her to teach in accordance with her vision. She explained,

> I have always known that I have to differentiate for my kids but this year I have two special needs students who absolutely cannot work with anyone else (because of severe anger issues) even though I always give them the option of doing so. Then, I have a handful of academically gifted students who are fast workers and perfectionists. They do not accept it when they do not get things on the first try. They are actually the most frustrated students during science because they have their way of doing it and it is not always the right way and they have a very hard time accepting that.

She also cited "time and the amount of information required by the NCSCOS that I am asked to put in these kids' heads for them to master" sometimes makes her "lose sight of my vision." She further explained that throughout the day "a lot of kids are coming and going and they miss things or if their pullout teacher is absent and they haven't been here the whole time I don't know what to do with them." Her belief that the NCSCOS did not "actually prepare students for life skills" was also a potential barrier of her being able to enact her vision. To further illustrate her belief, she drew on a math goal associated with teaching students about the area of triangles and acknowledged that if a student ever challenged her by asking why they needed to know about this particular concept that she would find it difficult to provide a reasonable answer. Ms. Winn also stated, "I wish I had more freedom to pursue students' interests versus having to teach all this (NCSCOS) inside this box before I can do any of that."

To best navigate through the obstacles discussed above, Ms. Winn explained that she tries to integrate her instruction whenever possible and pointed out that she is still learning how to best do this. She also cited that sharing planning responsibilities among her fourth grade team helped her plan for differentiated instruction.

Pointing out that her science experiences in her teacher preparation program touted inquiry as the most appropriate way to teach science she stated "It has always been stressed to do inquiry-based science so I try really hard to give them (students) enough background information so they'll know what to do with the materials I put in front of them. But I try not to give them everything they need to know and let them try to make those connections on their own." To assist with the varying background information that her students' possessed, she explained, "I try to present them with more of a question for our discovery rather than here is what it is, now show me how it works. After I give them the chance to work with the materials we'll come back together and kind of fill in the gaps for those who didn't quite get it." Related to the FOSS unit, she aimed for students to “understand what a magnet is, its properties and uses.” She also wanted students to be able to make connections to the real world about the uses of magnetism and electricity and believed that these connections would help students see how what they were learning as being important. Another goal she held for students’ science learning was to become aware of energy conservation.

Features of Ms. Winn’s vision. Based on Ms. Winn’s responses during the pre-study interview, having students make real-world connections was considerably important to her. Fostering students’ interests, persistence and independence were also features of her vision that she discussed. While Ms. Winn was the only teacher who articulated that she considered students’ interests, her concern with students’ persistence was shared with Ms. Landers and Ms. Lawson. Her focus on students’ independence was also a feature of Ms. Landers’ and Ms. Rose’s visions. Ms. Winn’s concern with developing students’ confidence was shared across all four teachers. Ms. Winn aimed for students to become problem-solvers and this feature of her vision seemed to be connected to the way she promoted inquiry.

Like Ms. Rose, Ms. Winn appeared very aware of the expectation to teach the goals and objectives provided by the NCSCOS. However, it appeared that Ms. Winn viewed the NCSCOS as a barrier for being able to assist students’ in making their learning connect to the real world, which was clearly a feature of her vision. Similar to Ms. Landers, Ms. Winn’s goal for students to become aware of energy conservation served as an avenue for her to connect what students were learning to the real world. Ms. Winn’s approach to inquiry, like all of the other teachers, included students working together with hands-on materials to figure out something, which seemed to be related to the feature of her vision that promoted students to become problem solvers. However, unique to her approach to inquiry was that she believed it was necessary to be explicit about the purpose of the inquiry before students had a chance to explore. She also believed it necessary to provide an explanation afterwards so that all students understood the content (see Table 36).

Table 36

Features of Ms. Winn's Vision

Students possess an awareness of or application of their learning to the real world
Students pursue interests
Students persist
Students possess independence
Students possess confidence
Students become problem-solvers
Students understand the uses of and properties of magnets

Vision-linked adaptations and rationales. Ms. Winn most frequently made vision-linked adaptations while teaching ($N = 25$) (see Table 37). Three features of her vision were promoted in about 80% of the vision-linked adaptations she made while teaching. The three features that were promoted the most frequently included that students become problem-solvers ($N = 9$), understand the uses of and properties of magnets ($N = 6$) and pursue interests ($N = 5$). When Ms. Winn made vision-linked adaptations, she most often changed the means by which objectives were met ($N = 13$)

and omitted/inserted an activity ($N = 8$) that together accounted for 84% of her vision-linked adaptations.

Table 37

Features of Ms. Winn's Vision Represented in Vision-linked Adaptations Made While Teaching

Feature of Vision Represented in Vision-linked Adaptations Made While Teaching	*TAT Adaptation Types					Total
	II	III	V	VI	VII	
Students possess an awareness of or application to the real world	1		1			2
Students pursue interests	2			3		5
Students possess confidence	2		1			3
Students become problem-solvers	4	1		3	1	9
Students understand the uses of and properties of magnets	4			2		6
Total	13	1	2	8	1	25

*TAT Adaptation Types: II – Changes the means by which objectives are met; III – Invents examples, analogy or metaphor; V – Suggests a different perspective to students; VI – Omits/inserts an activity; VII – Changes planned order of instruction

Ms. Winn's rationales indicated that the vision-linked adaptations that she made while teaching and during planning were mostly associated with her use of her knowledge of students or classroom dynamics to alter instruction, to help students make connections and to challenge or elaborate, which collectively accounted for about 70% of the rationales that she offered for the vision-linked adaptations she made while teaching and during planning (see Table 38).

Table 38

Features of Ms. Winn's Vision Represented in Thoughtfully Adaptive Teaching Rational Types

Feature of Vision Represented While Teaching and During Planning	*TAT Rational Types								Total
	B	C	D	E	F	G	I	J	
Students possess an awareness of or application to the real world		1	4		1				6
Students pursue interests				6				1	7
Students possess confidence				3		1			4
Students become problem-solvers	5	1	1	3		1			11
Students understand the uses of and properties of magnets		1	3	1	1	1	2		9
Total	5	3	8	13	2	3	2	1	37

*TAT Rationale Types: B – Challenge/Elaborate; C – To teach a specific strategy or skill; D – To help students make connections; E – Uses knowledge of students or classroom dynamics to alter instruction; F – Checking students understanding; G – Anticipation of upcoming difficulty; I – To manage time; J – to promote student engagement

In the following paragraphs a description of how and why Ms. Winn made vision-linked adaptations in which she promoted students to become problem-solvers, understand the uses of and properties of magnets and pursue their interests is provided.

Promoting students to become problem-solvers. Across five lessons (lesson numbers 5, 10, 11, 12, 13), Ms. Winn adapted in ways that provided opportunities for students to engage in problem-solving. When she made adaptations that promoted this feature of her vision, it appeared that the adaptations also promoted inquiry and challenges for students. Further, the vision-linked adaptations of this nature were associated with lessons in which students were building items such as magnet chains, circuits and electromagnets.

For lesson five, after students were successful in creating a magnetic chain, Ms. Winn instructed students to place non-magnetic items in between two magnets and indicated in her rationale that she aimed for students to figure out that the further away the two magnets were, the less magnetic force there was. She also indicated that she wanted to students to start thinking about this so they could begin thinking about the magnetic field. On another occasion, Ms. Winn challenged students to problem-solve the ways that they could make two light bulbs light up by building a circuit. She stated in her rationale that she wanted them to "be challenged by having to figure out how to incorporate the second light bulb into their circuit." During planning for lesson 12, Ms. Winn decided to give students the materials to build an electromagnet instead of leading them through the process. In her rationale, she indicated that the other three teachers were approaching the lesson in this way and that it sounded like a good way to help students learn how to think and problem-solve. In the final lesson of the unit, Ms. Winn was aware that a group of students had not explored the idea of wrapping a wire around a rivet to make the electromagnet stronger and asked students questions about what they had already tried. In doing so, she tried to lead them into realizing that they needed to try to wrap the wire around the electromagnet. She explained that she made this adaptation to help students solve the problem of making the electromagnet stronger.

As demonstrated in Ms. Winn's vision-linked adaptations in which she promoted opportunities for students to engage in problem-solving, she appeared to also promote a certain level of inquiry.

Promoting students to understand the uses of and properties of magnets. On nine occasions across four lessons (numbers 2, 3, 11 and 12), Ms. Winn made vision-linked adaptations that promoted students to better understand the uses of or properties of magnets. For example in lesson two, students shared the results of whether or not the test items were magnetic or non-magnetic. Ms. Winn recorded the results on the board. After she recorded their results, she asked the questions, “When we talk about conclusions, what do you notice here? What are some conclusions you would make?” In her rationale she stated that she, at that moment, realized that one of her students had been absent during the lesson and was not able to complete the activity and as a result was probably “sitting there and had absolutely no idea what we were talking about and so I figured that would be a good way to have it on the board for him to have kind of like a graphic organizer of what was magnetic and what was not so that later when we talk about magnets only sticking to steel or iron, he’ll have this knowledge to draw from.”

As Ms. Winn monitored small groups of students she noticed that students were discussing how the magnetite rock was sticking to metal items. Students appeared unaware that rocks existed that could be also be a magnet and were very interested in this. When Ms. Winn noticed this, she stopped and asked for students to explain why they thought the rock was sticking to metal items. The rationale she provided for this adaptation indicated that she aimed for students understand that the rock was magnetite and because of this it would stick to items made of iron or steel.

The next example demonstrates that Ms. Winn was more explicit about her intentions of promoting students understanding of the properties of magnets. She reminded students that when magnets are attracted to each other that the north and south poles were together. She told them that if they understood and could remember this that they could apply it to what they were about to learn with batteries. Her rationale indicated that they needed to be thinking about this because they would be using it when they created an electromagnet.   In the last lesson, Ms. Winn began the lesson by providing students with an explanation of magnetic force. Her rationale indicated that again she realized that two of her students had been absent and believed that they needed to understand magnetic force before engaging in trying to build an electromagnet.

When Ms. Winn promoted students to understand the uses of or properties of magnets, she often had specific students in mind. She also seemed to be anticipating upcoming difficulty for those students. It appeared that Ms. Winn viewed that this was a necessary foundation for students' further learning in terms of the unit.

Promoting students' interests. For six lessons (1, 3, 8, 9, 10, 11), Ms. Winn made seven adaptations that promoted students' interests and for many of the lessons, it appeared that she possessed significant knowledge of her students and adapted accordingly. For example during planning for lesson one, Ms. Winn decided to use a KWL chart on the smart board and to keep an inquiry chart and word bank from lesson to lesson. Her rationale indicated that she adapted in this way because she wanted to "tap into students' interests and place the information in a format they are used to seeing and enjoy working with." In another adaptation made during planning, Ms. Winn planned to show students a video of doughnut magnets with a pencil placed in the middle of them that created the illusion that they magnets were floating. Her rationale indicated that students would be interested in the video and that it might help them want to try it out.

In lesson eight, Ms. Winn omitted parts of the lesson where students were to suppose to be "conductor detectives" and explore various items around the room for ability to conduct electricity. Her rationale indicated that she thought students already understood the point of the lesson and that to continue on would just be overkill and would likely lead to then becoming uninterested. While this adaptation was not aimed at promoting students' interests, it was made to at least maintain students' interest and therefore was considered a vision-linked adaptation promoting students' interest.

During lesson ten, Ms. Winn promoted students' interest by relating students' schematic diagrams to what electricians use. She told students that they were being like electricians and that if they learned about how to use the schematic diagrams that they could work as an electrician. She explained that making this connection for students was relatively easy and that they focus of the lesson helped create this interest for students.

In lesson eleven, students' interest was promoted when Ms. Winn gave students the choice of creating a circuit with either motors or lights. She explained that she provided this choice as way to keep students focused and interested in making their circuits. As illustrated in these descriptions, Ms. Winn mostly used her knowledge of students when she made vision-linked adaptations that promoted students to be interested in science instruction.

A discussion of Ms. Winn's vision-linked adaptations. Ms. Winn's most frequent vision-linked adaptations made while teaching ($N = 25$) and during planning (N

= 12) promoted students to engage in problem-solving (*N* = 9), understand the uses of and properties of magnets (*N* = 6) and nurtured their interests in science (*N* = 5). Collectively, the vision-linked adaptations made to promote the three features in Ms. Winn's vision represent about 84% of her vision-linked adaptations and about 26% of the total adaptations that she made while implementing this unit.

The nature of her vision-linked adaptations seemed to indicate that she was well aware of her students' needs and wanted to provide them with relevant (interesting) and challenging opportunities to learn. It also appeared that Ms. Winn's aim to promote problem-solving was connected to the way she approached inquiry.

Throughout the unit implementation, Ms. Winn never made a vision-linked adaptation to promote students' persistence or independence. The vision-linked adaptations that she made represented five of the seven TAT adaptation types. She never made vision-linked adaptations by modifying the lesson objective (TAT adaptation type I) or by inserting a mini-lesson (TAT adaptation type IV), which indicated that to some extent she was able to apply a variety of strategies to assist students in ways that were rooted in her vision. For her vision-linked adaptations, she never provided a rationale that indicated she adapted because the lesson objective was not met (TAT Rationale Type A) or to manage student behavior (TAT Rationale Type H).

Ms. Winn's vision-linked adaptations and target students' learning. Ms. Winn made 37 vision-linked adaptations and as discussed above, all but two features of her vision were represented in her vision-linked adaptations. In regards to her target students' learning, Ms. Winn's target students' had a 32% average learning gain as measured on the unit pre- and posttest (see Table 39). Comparisons made across Ms. Winn's target students' unit pre- and posttest and learning gains indicated the following findings (see Table 40).

Table 39

Ms. Winn's Target Students' Average Learning Gains

Vision-linked Adaptations			**Mean % Correct for Target Students**		
Teaching	**Planning**	**Total**	**Pretest**	**Posttest**	**Gain**
25	12	37	57%	72%	32%

Table 40

Ms. Winn's Target Students' Unit Pre- and Posttest and Learning Gains

Student Achievement Level	**Unit Pretest % Correct**	**Unit Posttest % Correct**	**% Gained of Possible Percentage Points**
Low	44%	59%	27%
Low	48%	61%	25%
Average	46%	72%	48%
Average	67%	76%	27%
High	63%	76%	35%
High	76%	83%	27%

One of Ms. Winn's high-achieving target student's unit pretest score indicated a higher degree of existing knowledge about magnetism and electricity than all other target students in Ms. Winn's classroom with a score of 76%. Ms. Winn's target students' scores on the unit pretest also indicated a clear distinction between two groups of students rather than three. That is, the low-achieving students and one average-achieving student shared similar scores while both high-achieving students and the other average-achieving student scored similarly.

Target students' unit posttest scores indicated that a high-achieving student scored 83% of the possible points. An examination of target students' unit posttest scores also indicated the following that collectively, the average- and high-achieving students received 72% or more of the 46 raw score points, indicating, that at the end of the unit they had a substantial understanding of magnetism and electricity as measured by the unit posttest (of at least 70% of the total 46 available points). The low-achieving students, scored similarly on the unit posttest and their scores did not indicate a substantial understanding of magnetism and electricity.

The percentage of possible points gained indicated that an average-achieving student gained a higher percentage of points possible from the unit pre- and posttest (48% of the possible points). While it appears that all of Ms. Winn's students' understanding of magnetism and electricity benefitted, those who benefitted most, as indicated by the highest percentage of gain scores from the unit pre- and posttest scores was one average- and one high-achieving student.

Ms. Winn made many vision-linked adaptations in which she promoted students to understand the uses of and/or the properties of magnets. Given the alignment of this feature of her vision for students' learning with the FOSS unit (discussed in Chapter I) it seems sensible that all of her students would experience learning gains. That is, the nature of the vision-linked adaptations of this sort promoted as aspect of students' learning that was measured by the unit posttest.

Another interesting finding is that Ms. Winn's vision-linked adaptations represented five of the seven TAT adaptation types, indicating that to some extent vision-linked adaptations made in a variety of ways may benefit students' learning. Given that Ms. Winn never provided a rationale that she made a vision-linked adaptation because the objectives were not met and that her low-achieving students' unit posttest scores indicated a shallow understanding (score of less than 70% of total 46 points) this may indicate that she was not aware of objectives not being met or that she was measuring students' ability to meet the lesson objectives in ways that were not examined in this study.

To summarize, Ms. Winn's target students' science learning as measured in this study indicated positive outcomes and Ms. Winn adapted in accordance with her vision across a variety of TAT adaptations and rationale types. Like the other teachers in this study, her vision held features that quite possibly could benefit students' learning in ways that were not measured in this study. In the following section the nature of the relationship between teachers' vision-linked adaptations and students' learning is described and discussed.

The Nature of the Relationship between Teachers' Vision-linked Adaptations and Students' Learning

An examination across all four teachers' vision-linked adaptations and their students' science learning indicated a number of patterns that provide insight about the nature of the relationship between the variables of teachers' vision-linked adaptations and students' science learning. First, it appears that making more vision-linked adaptations is related to positive student outcomes. For example, Ms. Rose who made the most vision-linked adaptations (60) and proportionally the most vision-linked adaptations (60/77 = 78%) also had target students who experienced the most learning gains from pre- to posttest (41%). When comparing the learning gains of Ms. Landers', Ms. Lawson's and Ms. Winn's target students and the proportion of vision-linked adaptations made (see Table 1), the pattern suggests that the differences are due to the proportion of vision-linked adaptations made during planning. For example, all three teachers shared a similar proportion of total vision-linked adaptations made (while teaching and during planning combined), yet, their students' learning gains did not indicate similar gains. However, of these three teachers, Ms. Winn made proportionally the most vision-linked adaptations during planning (32%) while Ms. Landers (20%) and Ms. Lawson (18%) (see Table 41) shared similar proportions of vision-linked adaptations made during planning.

Table 41

Total Percent of Vision-linked Adaptations Compared to Percent Made during Planning and Target Students' Learning Gains

Teacher	Total % of Vision-linked Adaptations	% of Vision-linked Adaptations Made during Planning	Target Students' Learning Gains
Landers	41%	20%	10%
Lawson	48%	18%	14%
Winn	48%	32%	32%

Consequently, it appeared that this accounted in part for the differences observed among all three teachers' target students' learning gains. Ms. Winn's target students made 32% learning gains, while Ms. Landers' target students gained 10% and Ms. Lawrence's target students' learning gains were 14%. Given these findings, perhaps when teachers make a substantive number of vision-linked adaptations during planning they are able to adapt in robust ways that positively impact students' science learning. Further, it may be that when teachers are able to make substantive adaptations during planning, they do not need to make as many adaptations while teaching because during planning they have been able to anticipate the needs of their students and respond accordingly.

Another finding made from these comparisons indicates that when teachers make vision-linked adaptations in a variety of ways, their students' learning seem to benefit (see Table 42).

Table 42

TAT Adaptation and Rational Types Represented in Vision-linked Adaptations and Students' Learning Gains

	Number TAT Adaptation Types Represented in Vision-linked Adaptations	**Number of TAT Rationale Types Represented in Vision-linked Rationales**	**Target Students' Learning Gains**
Landers	4	7	10%
Lawson	3	8	14%
Rose	7	8	41%
Winn	5	8	32%

That is, when compared across all four teachers, we find that the more varied the adaptations (based on previous TAT adaptation and rationale types) that teachers made, the more their students' tended to learn. It appears that for these teachers, possessing a vision and acting in accordance with that vision by making a variety of vision-linked adaptations, their students' learning may benefit.

Further, it is possible too that Ms. Rose's and Ms. Winn's target students' experienced such learning gains in part due to Ms. Rose's and Ms. Winn's well-developed science backgrounds. Ms. Rose, as previously indicated in Chapter III, was a member of a two-year science cohort team. Ms. Winn, during the pre-study interview described how the intense focus on science at Virginia Polytechnic Institute and State University allowed her to develop an in-depth knowledge of science and inquiry. She also completed her student teaching in a science classroom as a part of her graduate studies. Both teachers had well-developed science backgrounds. Given that Ms. Winn had a Master's Degree and five years of teaching experience and Ms. Rose had a Bachelor's Degree and two years of teaching experience, one would expect to find that Ms. Winn's students made the most learning gains. However, this was not the case. While Ms. Rose made the same number of adaptations as Ms. Winn, Ms. Rose made many more vision-linked adaptations in a variety of ways (representing all seven TAT adaptation types) for a variety of reasons (representing eight TAT rationale types) and her target students made the most learning gains. Perhaps, when teachers merge their professional knowledge (content and pedagogical) with their visions of teaching to make vision-linked adaptations, students' science learning can benefit, indicating that this is the mark of an effective teacher.

A Pearson's correlation indicated that there was a significant correlation of moderate strength (with $r = .41 - .60$) between the frequency of teachers' vision-linked adaptations and students' unit posttest scores ($r\ (21) = .57, p < .01$). Teachers who made more vision-linked adaptations also tended to have students who scored higher on the unit posttest. R-squared was .37, implying that 37% of variance for the frequency of vision-linked adaptations was associated with the variance in students' unit posttest scores. These statistical results should be interpreted cautiously as this study examined only four teachers and 23 of their students.

Summary

The purpose of this study was to examine the instructional adaptations of four fourth grade teachers while teaching and during planning when implementing the *Full Option Science System* (*FOSS*) "Magnetism and Electricity" unit. Teachers' vision-linked adaptations were a major focus of this study as well as the nature of the relationship between teachers' vision-linked adaptations and their students' science learning, narrowly defined by selected students' scores on the FOSS "Magnetism and Electricity" unit pre and posttest.

This chapter has provided and discussed the findings of the study. First, the frequencies of adaptations and rationales made during teaching and planning were presented and discussed. Next, the four teacher cases were presented with the discussion limited to a description of teachers' vision-linked adaptations and their target students' learning. Then, the nature of the relationship between teachers' vision-linked adaptations and students' science learning was presented. To conclude this chapter, a summary of this study's major findings are bulleted below:

- Teachers made many more adaptations and vision-linked adaptations while teaching than during planning.
- The more adaptations and vision-linked adaptations that teachers made, the higher their students' performance on the posttest and there was a statistically significant correlation between the frequency of teachers' vision-linked adaptations and students' posttest scores.
- The more the lesson approached open inquiry, the more adaptations and vision-linked adaptations were made.
- More adaptations were made in science when compared to studies examining adaptations in literacy.
- Science teachers most frequently changed the means by which objectives were met, whereas literacy teachers in previous studies most frequently invented an example, analogy or metaphor
- Science teachers most frequently indicated that they adapt to help students make connections and rarely because the objectives were not met. Whereas, literacy teachers in previous studies most frequently indicated that they make adaptations because the objectives were not met.
- Making vision-linked adaptations in a variety of ways benefits students' science learning.

In Chapter V, I discuss the implications of these findings for teacher educators, acknowledge the limitations of this study and provide suggestions for future thoughtfully adaptive teaching research.

CHAPTER V

IMPLICATIONS

In this chapter I first provide a summary of the findings and then discuss the implications of these findings for researchers who are interested in thoughtfully adaptive teaching and science and literacy instruction in the elementary schools. Then the practical implications of this study are provided and finally the limitations of this study are acknowledged.

Summary of the Findings

This study examined four fourth grade teachers' instructional adaptations made while teaching and during planning when implementing the *Full Option Science System* (*FOSS*) "Magnetism and Electricity" unit. I especially focused on teachers' vision-linked adaptations and the nature of the relationship between teachers' vision-linked adaptations and their students' science learning.

The findings of this study clearly inform our understanding of the intersection of thoughtfully adaptive teaching (while teaching and during planning) and teachers' visions in relation to students' learning. For example, this study found that many more adaptations and vision-linked adaptations were made while teaching than during planning. Additionally, a statistically significant positive correlation existed between teachers' vision-linked adaptations and students' unit posttest scores. That is, the more vision-linked adaptations that teachers tended to make, the higher their students' performance tended to be. Moreover, this study enhances our understanding of the significant relationship between openness of tasks and adaptations made while teaching. When teachers engaged students in completing open tasks, the lessons yielded more adaptations and vision-linked adaptations. Therefore, we can conclude that inquiry-based science, due to the open nature of the tasks associated with such instruction requires that teachers engage in thoughtfully adaptive teaching. Further, the teachers in this study adapted in distinctly different ways and for different reasons than teachers in TAT literacy studies. For example, the science teachers in this study most frequently changed the means by which objectives were met to help students make connections and rarely because the objectives were not met. However, literacy teachers most frequently invented an example, analogy or metaphor because the objectives were not met. In sum, the evidence from this study indicated that the most effective science teachers approached instruction from a stance of inquiry, which was associated with the open tasks that they assigned and made thoughtful vision-linked adaptations. Clearly then, these findings have implications for both researchers and practitioners. These implications are further pointed out with recommendations of how both researchers and practitioners can best respond in light of the information gleaned from this study.

Implications for Researchers

The findings from this study suggest future areas of research in TAT. We need to examine more facets of students' learning. What do students learn that cannot be measured in the traditional unit pre- and posttests? Future TAT studies need to address other ways to capture students' learning. This may be done by conducting studies where researchers observe what students do when teachers make instructional adaptations. Conducting interviews with students about what they know and are learning would also assist with a better understanding of all the knowledge that students possess. Adding components of student observations and interviews along with pre- and posttests so that these three data sources can be triangulated in future TAT studies will allow for a more comprehensive understanding of students' learning. Related to students' learning, future studies need to examine students' retention of learning when teachers enact their visions through TAT. Similarly, future studies should examine students' learning with teachers who explicitly share their visions with students and enact their visions through their adaptations. Would students' learning benefit if they clearly understood their teachers' larger goals for learning? If students' learning did benefit from the teacher sharing the vision she/he holds for them, then would this impact the kinds of adaptations the teacher makes?

Future TAT studies need to continue to examine TAT in science with many more teachers and explore why science teachers tend to make adaptations by changing the means by which objectives were met whereas literacy teachers typically adapt by inventing an example, analogy or metaphor. Similarly, we need to continue to examine TAT in science to find out why science teachers adapt most often to help students make connections and rarely because the objectives of lessons are not met whereas literacy teachers report making adaptations most frequently because the objectives of the lessons are not met. Are these differences due to the nature of the subject matter? What are the lessons that could be learned about how we instruct teachers to teach in these two subject areas by further examining TAT in science?

To summarize, there is still work to do in understanding TAT and the nature of the relationship of TAT with student learning. This work may be well suited to be pursued in collaboration with teachers as professional development exercises. That is, examining TAT through studies that provide opportunities for teachers to examine and reflect deeply about their visions and thoughtfully adaptive teaching may be productive in shedding more light on teachers' visions and TAT while at the same time assisting teachers to develop their visions and professional knowledge in ongoing sustained ways so that students' learning may benefit.

Implications for Practitioners

Although these findings are of importance across all content areas, it appears that they are of particular importance to science teacher educators. If students are to realize the goals associated with "Scientific Literacy for All" we know that they must have opportunities to engage in inquiry. In this study there was overwhelming evidence that inquiry-based science instruction prompted teachers to make adaptations in general and vision-linked adaptations. The findings of this study revealed that as lessons in science approached open inquiry, teachers tended to make more adaptations in general and more vision-linked adaptations. Therefore, while science teacher educators continue to promote and develop teachers' abilities for inquiry-based instruction, it is also imperative to attend to both teachers' development of adaptive teaching and vision for teaching.

The in-depth description of how teachers made vision-linked adaptations and the circumstances surrounding those vision-linked adaptations in this study provides an appropriate place to begin with efforts to help shape teachers' adaptive teaching capacities and visions for teaching science. Teacher educators may use this information as a guide for instructing teachers about how to best adapt their teaching and about where efforts are needed to shape teachers visions so that they too view the importance of an inquiry-based approach to science. We may begin by intentionally preparing students for the complexities that are associated with inquiry and insist that preservice and in service teachers examine their own visions for teaching as a guide for effective ways to navigate through the complexities that they are bound to eventually face when they implement inquiry-based instruction.

First, teacher educators may begin by intentionally having their students examine their personal visions for teaching and what practices may surface as a result as possessing certain features of vision. If we insist that our candidates develop and anticipate the teacher they want to be, then we can help them become this teacher by rooting discussions of teaching and of their practice in their visions for teaching. For example, if our teacher candidates aim to have their future students construct their own knowledge from real-world experiences that they provide in the classroom then we can use this to help them develop practices that reflect such and we can hold them accountable for enacting this with their students. On the other hand, when we see our candidates experiencing tension between the enactment of their vision and the context in which they are working, or not enacting their vision, then we can use their visions as a source to help them connect their instruction to best practices and professional knowledge. Developing teachers' visions in these ways may be effective in producing teachers who are able to enact and use their visions to guide their instructional decisions.

In this study, the teacher who made the most vision-linked adaptations during planning most often made a change in the curriculum materials. This finding speaks to the importance of teacher educators also assisting teachers in their development of how to critically evaluate curriculum materials and make decisions about how best to implement and adapt the curriculum materials to best meet the needs of their students and instructional contexts. One way to do this may be to require that students thoughtfully adapt curriculum materials.

For example, if we understand that science teachers who use curriculum materials (like the ones in this study) tend to change the means by which objectives are met, then we need to point this out to preservice and in service teachers alike and provide spaces for them to think about how they would most effectively change the means of meeting lesson objectives. Further, we need to provide the experiences for both preservice and in service teachers to enact the ways they have envisioned so that they can then reflect for themselves about the effectiveness of such changes. Developing teachers' capacities of TAT is critical so that teachers can be best prepared to be responsive to students' needs. An example of how we have begun to think about how best to do this involves our preservice teachers in thoughtfully adapting science curriculum materials. This project is described below and could be easily implemented across other methods courses in teacher education programs.

Currently, in our science methods courses at UNCG, we require our students to thoughtfully adapt science curriculum materials. This assignment requires students to work in groups of three to identify science curriculum materials, examine those materials in light of inquiry, content and alignment with standards and to work together to adapt the materials for a particular purpose and grade level. That is, our preservice teachers must decide what they will teach, who they will teach and how they will teach while using the curriculum materials as a support to help them reach the goals that they identify. Then we require our students to teach the lessons that they develop and to reflect about how the adaptations they made influenced their students' participation in and science learning. We are starting to hear our students say, "I thoughtfully adapted when…" indicating that they are thinking about and reflecting on their development of becoming thoughtfully adaptive teachers. This project is aimed at developing our students' professional knowledge and needs to be further developed to include our students' visions for teaching.

This study found many more adaptations than found in previous TAT research where studies were conducted in a school system that required compliancy of teachers to follow certain programs of instruction. This study also provided evidence that when teachers are thoughtfully adaptive they impact students' learning in positive ways. These findings highlight the importance of the context and teachers' propensity to be thoughtfully adaptive, which was linked to student learning. Principals and school system administrators ought to be well-advised about the impact that such rules and policies have on teachers' autonomy and their instructional decisions. Perhaps placing more efforts on developing teachers' capacities to be thoughtfully adaptive and their visions for teaching rather than their abilities to implement programs of instruction with fidelity is a more productive way to ensure effective teaching and student learning.

Limitations of this Study

The limitations of this study (four teachers, one unit of instruction, and 23 target students), reduce our ability to make generalizations. Examining teachers' adaptations in only one unit of instruction limits the degree to which we may apply our findings to other units of instruction in science, to instruction in other subject areas or integrated studies. There were no criteria for teachers to follow when they chose low-, average- and high-achieving students. This may have impacted which students were chosen and we do not have a clear idea about what it means for specific teachers for a student to be a low-, average- or high-achieving student. The way students' science learning was measured in this study was limited to their scores on a single test. This was a very narrow way of defining students' learning and therefore, limits our understanding of other learning that students experienced. The number of target students examined in this study (23) also limits the extent that we may apply these findings to other fourth grade students.

Conclusion

If science teachers are to respond adequately to the needs of students as they occur while teaching, then they must be thoughtfully adaptive. Developing teachers' visions for science teaching is also important. For example, the teacher in this study held a clear vision for inquiry-based science instruction. She drew on this clear vision and was able to make vision-linked adaptations that provided inquiry experiences for her students.

In other words, like others (Hammerneess, 2006; McElhone et al., 2009) have found, the clarity of her vision allowed her to be proactive in enacting this portion of her vision.

Additionally, the development of teachers' ability to critically evaluate curriculum materials is imperative. Continuing this important work of examining TAT may be well-suited as professional development for teachers. That is, conducting this important research as partners with teachers can assist teachers to develop their thoughtfully adaptive teaching capacities and their visions for teaching while as researchers, we can learn more about the intersection of TAT and teachers' visions. As teacher educators who conduct research, we can learn more about the development of teachers' visions and of teachers becoming thoughtfully adaptive, which may be used in our instruction of teachers.

We now have a deeper understanding of TAT that is associated with teachers who possess various backgrounds and in different phases of their development. These descriptions can be used as a guide for instructing teachers about how to best adapt their teaching and where efforts are needed to shape teachers visions so that they too view the importance of an inquiry-based approach to science.

REFERENCES

Allington, R. L., & Johnston, P. (2002). *Reading to learn: Lessons from exemplary fourth-grade classrooms*. New York: Guilford Press.

Berliner, D.C (2001). Learning about and learning from expert teachers. *International Journal of Educational Research, 35,* 463–482.

Borko, H., Liston, D., & Whitcomb, J. A. (2007). Genres of empirical research in teacher education. *Journal of Teacher Education, 58,* 3-11.

Bransford, J., Darling-Hammond, L., & LePage, P. (2005). Introduction. In L. Darling-Hammond & J. Bransford (Eds.), *Preparing teachers for a changing world: What teachers should learn and be able to do* (pp. 1-39). San Francisco: Jossey-Bass.

Bransford, J., Derry, S., Berliner, D., Hammerness, K., & Beckett, K. L. (2005). Theories of learning and their roles in teaching. In L. Darling-Hammond & J. Bransford (Eds.), *Preparing teachers for a changing world: What teachers should learn and be able to do* (pp. 40-87). San Francisco, CA: Jossey-Bass.

Bromme, R. (1982). *How to analyze routines in teachers' thinking processes during lesson planning.* Paper presented at the annual meeting of the American Educational Research Association, New York.

Brown, M. (2009). Toward a theory of curriculum design and use: Understanding the teacher tool relationship. In J. Remillard, B. Herbel-Eisenman, & G.

Lloyd (Eds.), *Mathematics teachers at work: Connecting curriculum materials and classroom instruction* (pp. 17-37). New York: Routledge.

Clark, C. M., & Elmore, J. L. (1981). *Transforming curriculum in mathematics, science, and writing: A case study of teacher yearly planning* (Research Series No. 99). East Lansing, MI: Michigan State University, Institute for Research on Teaching.

Clark, C. M., & Peterson, P. L. (1986). Teachers' thought processes. In M. Wittrock (Ed.), *Handbook of research on teaching* (3rd ed., pp. 255-296). New York: Macmillan.

Clark, C., & Yinger, R. (1979a). Teachers thinking. In P. Peterson and H. Walberg (Eds.), *Research on teaching*. Berkeley, CA: McCutchan Press.

Clark, C., & Yinger, R. (1979b). *Three studies of teacher planning* (Research series no. 55). East Lansing, MI: Michigan State University, Institute for Research on Teaching.

Creswell, J. W. (2003). *Research design: Qualitative, quantitative, and mixed methods approaches* (2nd ed.). Thousand Oaks: Sage.

Creswell, J. W. (2005). *Educational research: Planning, conducting, and evaluating quantitative and qualitative research* (2nd ed.). Upper Saddle River, NJ: Pearson.

Creswell, J. W., & Plano Clark, V. L. (2007). Designing and conducting mixed methods research. Thousand Oaks, CA: Sage.

Darling-Hammond, L., & Baratz-Snowden, J. (Eds.). (2005). *A good teacher in every classroom.* San Francisco: Jossey-Bass.

Darling-Hammond, L., & Bransford, J. (Eds.). (2005). *Preparing teachers for a changing world: What teachers should learn and be able to do*. San Francisco: Jossey-Bass.

Davis, S. (2009). Case studies of two teachers: The knowledge teachers draw upon to adapt. Ph.D. dissertation, The University of North Carolina at Greensboro, United States—North Carolina. Retrieved October 21, 2009, from Dissertations & Theses @ University of North Carolina at Greensboro. (Publication No. AAT 3355946).

Davis, E. A., & Krajcik, J. S. (2005). Designing educative curriculum materials to promote teacher learning. *Educational Researcher, 34*(3), 3-14.

Denscombe, M. (2008, July). Communities of Practice: A Research Paradigm for the Mixed Methods Approach. *Journal of Mixed Methods Research, 2,* 270-283.

Duffy, G. G. (2002). Visioning and the development of outstanding teachers. *Reading Research and Instruction, 41,* 331-344.

Duffy, G. G., & Hoffman, J. V. (2002). Beating the odds in literacy education: Not the "betting on" but the "bettering of" schools and teachers. In B. M. Taylor & P. D. Pearson (Eds.), *Teaching reading: Effective schools, accomplished teachers* (pp. 375-387). Mahwah, NJ: Lawrence Erlbaum.

Duffy, G. G., Miller, S. D., Parsons, S. A., & Meloth, M. (2009). Teachers as metacognitive professionals. In D. J. Hacker, J. Dunlosky, & A. C. Graesser (Eds.), *Handbook of metacognition in education* (pp. 240-256). Mahwah, NJ: Lawrence Erlbaum.

Duffy, G. G., Miller, S. D., Kear, K. A., Parsons, S. A., Davis, S. G., & Williams, J. B. (2008). Teachers' instructional adaptations during literacy instruction. In Y. Kim,

V. J. Risko, D. L. Compton, D. K. Dickinson, M. K., Hundley, R. T. Jimenez, K. M. Leander, & D. W. Rowe (Eds.), *57th Yearbook of the National Reading Conference* (pp. 160-171). Oak Creek, WI: National Reading Conference.

Duffy, G., Webb, S., Kear, K., Leiphart, R., Parsons, S., & Miller, S. (2006, December). *Does thoughtfully adaptive teaching exist? First steps in a longitudinal study of literacy teaching and literacy education.* A paper presented at the National Reading Conference, Los Angeles.

Fairbanks, C. M., Duffy, G. G., Faircloth, B. S., He, Y., Levin, B., Rohr, J., & Stein, C. (2010). Beyond knowledge: Exploring why some teachers are more thoughtfully adaptive than others. *Journal of Teacher Education, 61*(2), 161-171.

Feiman-Nemser, S. (2001). From preparation to practice: Designing a continuum to strengthen and sustain teaching. *Teachers College Record, 103,* 1013-1055.

Flavell, J. H. (1979). Metacognition and cognitive monitoring: A new area of cognitive Developmental inquiry. *American Psychologist, 34,* 906–911.

Flavell, J. H. (1987). Speculations about the nature and development of metacognition. In F. E. Weinert & R. H. Kluwe (Eds.), *Metacognition, motivation, and understanding*. Hillsdale, NJ: Lawrence Erlbaum.

Forbes, C. T., & Davis, E. A. (2008). The development of preservice elementary teachers' curricular role identity for science teaching. *Science Education, 92*(5), 909-940.

Full Option Science System. (2009). *What is FOSS?* [Online]. Available: http://lhsfoss.org/introduction/index.html. Berkeley, CA: University of California at Berkeley, Lawrence School of Science.

Grossman, P. L. (1995). Teacher's knowledge. In L. W. Anderson (Ed.), *International encyclopedia of teaching and teacher education* (2nd ed.) (pp. 20-24). Kidlington, Oxford, OK: El Seyer Science Ltd.

Hammerness, K. (2000). Seeing through teachers' eyes: An exploration of the content, character and role of teachers' vision (Doctoral dissertation, Stanford University, 2000). *Dissertation Abstracts International, 60*(08), 2797.

Hammerness, K. (2001). Teachers' visions: The role of personal ideals in school reform. *Journal of Educational Change, 2,* 143-163.

Hammerness, K. (2003). Learning to hope, or hoping to learn? The role of vision in the early professional lives of teachers. *Journal of Teacher Education*, *54*(1), 43-56.

Hammerness, K. (2004). Teaching with vision: How one teacher negotiates the tension between high ideals and standardized testing. *Teacher Education Quarterly*, *Fall,* 33-43.

Hammerness, K. (2006). *Seeing through teachers' eyes: Professional ideals and classroom practices*. New York: Teachers College Press.

Hammerness, K. (2008). "If you don't know where you are going, any path will do": The role of teachers' visions in teachers' career paths. *The New Educator, 4*(1), 1-22.

Hammerness, K., Darling-Hammond, L., Bransford, J., Berliner, D. C., Cochran-Smith, M., McDonald, M., & Zeichner, K. (2005). How teachers learn and develop. In L.

Darling Hammond & J. Bransford (Eds.), *Preparing teachers for a changing world: What teachers should learn and be able to do* (pp. 358-389). San Francisco, CA: Jossey Bass.

Hansen, D. (1995). *The call to teach.* New York: Teachers College Press.

Helmke, A., & Weinert, F. E. (1997). Conditions of academic achievement. In F. E. Weinert (Ed.), Psychologie des Unterrichts und der Schule (pp. 71e176). Go¨ttingen, Deutschland: Hogrefe.

Huebner, D. (1987). The vocation of teaching. In F. S. Bolin & J. M. Falk, *Teacher renewal*. New York: Teachers College Press.

Huebner, D. (1996). Teaching as a moral activity, *Journal of Curriculum and Supervision*, *11*(3), 267-275.

Kauffman, D. (2002, April). *A search for support: Beginning elementary teachers' use of mathematics curriculum materials.* Paper presented at the annual conference of American Educational Research Association, New Orleans, LA.

Kear, K. (2009). *Teachers' adaptations and rationales as they relate to openness of task and student motivation. ProQuest Dissertations and Theses.* Retrieved from http://search.proquest.com/docview/304963745?accountid=14604.

Korthagen, F. A. J. (2004). In search of the essence of a good teacher: Towards a more holistic approach in teacher education. *Teaching and Teacher Education, 20*(1), 77-97.

Lin, X., Schwartz, D. L., & Hatano, G. (2005). Toward teachers' adaptive metacognition. *Educational Psychologist, 40*(4), 245-255.

Lincoln, Y. S., & Guba, E. G. (1984). *Naturalistic inquiry*. Beverly Hills, CA: Sage.

Marland, P. (1977). *A study of teachers' Interactive thoughts.* Unpublished dissertation, University of Alberta.

Maxwell, J. A. (1996). *Qualitative research design: An interactive approach*. Thousand Oaks: Sage.

Maxwell, J. A. (2005). *Qualitative research design: An interactive approach*. Thousand Oaks, CA: Sage.

McElhone, D., Hebard, H., Scott, R., & Juel, C. (2009). The role of vision in trajectories of literacy practice among new teachers. *Studying Teacher Education: A Journal of Self-Study of Teacher Education Practices, 5*(1).

McLoughlin, A., & Dana, T. (1999). Making science relevant: The experiences of prospective elementary school teachers in an innovative science content course. *Journal of Science Teacher Education, 10*(2), 69-91.

McNay, M., & Graham, R. (2007). Can cooperating teachers help student teachers develop a vision of education? *The Teacher Educator, 42*(3), 224-236.

Meece, J., Herma, P., & McCombs, B., (2003). Relations of learner-centered teaching practices to adolescents' achievement goals. *International Journal of Educational Research, 39,* 457-475.

Meloth, M. S., & Deering, P. D. (1999). The role of the teacher in promoting cognitive processing during collaborative learning. In O'Donnell & King (Eds.), *Cognitive Perspectives on Peer Learning*. Mahwah, NJ: Lawrence Erlbaum.

Miles, M. B., & Huberman, A. M. (1994). *Qualitative data analysis: An expanded sourcebook* (2nd ed.). Thousand Oaks, CA: Sage.

Morse, J. (1991). *Qualitative Nursing Research: A Contemporary Dialogue.* Newbury Park, CA: Sage Publications.

O'Conner, E. A., & Fish, M. C. (1998). *Differences in the classroom systems of expert and novice teachers.* Paper presented at the meetings of the American Educational Research Association, San Diego, CA.

Olson, J. (1981). Teacher influence in the classroom: A context for understanding curriculum change. *Instructional Science, 10,* 259-275.

Palmer, P. J. (1998). The heart of the teacher: Identity and integrity in teaching. Available: http://www.newhorizons.org/strategies/character/palmer.htm.

Palmer, P. J. (2008). Teaching with heart and soul: Reflections on spirituality in teacher education. Retrieved August 15, 2009, from Center for Courage and Renewal, http://www.couragerenewal.org/parker/writings/heart-and-soul.

Parsons, S. (2008). *Case studies of four teachers: The openness of the tasks they implement, the adaptations they make, and the rationales they offer for adapting.* Ph.D. dissertation, The University of North Carolina at Greensboro. Retrieved October 21, 2009, from Dissertations & Theses at the University of North Carolina at Greensboro. (Publication No. AAT 3307319).

Parsons, S. A., Davis, S. G., Scales, R. Q., Williams, J. B., & Kear, K. (2010). How and why teachers adapt their literacy instruction. In S. Szabo, M. B. Sampson, M. Foote, & F. Falk-Ross (Eds.), *Mentoring literacy professionals: Continuing the* *spirit of CRA/ALER after 50 years* (Vol. 31, pp. 221-236). Commerce, TX: Association of Literacy Educators and Researchers.

Randi, J., & Corno, L. (2000). Teacher innovations in self-regulated learning. In M. Boekaerts, P. R. Pintrich, & M. Zeidner (Eds.), *Handbook of self-regulation* (pp. 651-685). San Diego, CA: Academic Press.

Remillard, J. T. (1999). Curriculum materials in mathematics education reform: A framework for examining teachers' curriculum development. *Curriculum Inquiry, 29*(3), 315-342.

Remillard, J. T. (2000). Can curriculum materials support teachers' learning? Two fourth grade teachers' use of a new mathematics text. *Elementary School Journal, 100*(4), 331-350.

Rohr, J. P. (2005). *The examination of prospective teachers' initial and developing vision.* Unpublished doctoral dissertation, University of North Carolina at Greensboro.

Scales, R. Q. (2009). *Teaching adaptations as they are related to academic task and student engagement.* Unpublished doctoral dissertation, The University of North Carolina at Greensboro.

Schemp, P. G., Manross, D., Tan, S. K. S., & Fincher, M. D. (1998). Subject expertise and teachers' knowledge. *Journal of Teaching Physical Education, 17,* 342–356.

Schon, D. A. (1983). *The reflective practitioner: How professionals think in action.* New York: Basic Books.

Shavelson, R., & Borko, H. (1979). Research on teachers' decisions in planning instruction. *Educational Horizons, 57*(4), 183-189.

Shavelson, R., Caldwell, J., & Izu, T. (1977). Teachers' sensitivity to the reliability of information in making pedagogical decisions. *American Educational Research Journal, 14,* 83-97.

Sherin, M., & Drake, C. (2009). Curriculum strategy framework: investigating patterns in teachers' use of a reform-based elementary mathematics curriculum. *Journal of Curriculum Studies, 41*(4), 467-500.

Shulman, L. S., & Shulman, J. (2004). How and what teachers learn: A shifting perspective. *Journal of Curriculum Studies, 36,* 257-271.

Snow, C. E., Griffin, P., & Burns, M. S. (Eds.). (2005). *Knowledge to support the teaching of reading: Preparing teachers for a changing world*. San Francisco: Jossey-Bass.

Squire, K. D., MaKinster, J. G., Barnett, M., Leuhmann, A., & Barab, S. A. (2003). Designed curriculum and local culture: Acknowledging the primacy of classroom culture. *Science Education, 87,* 468-489.

Srivastava, P., & Hopwood, N. (2009). A practical framework for qualitative data analysis. *International Journal of Qualitative Methods, 8*(1), 76-84.

Tashakkori, A., & Teddlie, C. (1998). Mixed methodology: Combining qualitative and quantitative approaches. Thousand Oaks, CA: Sage.

Tashakkori, A., & Teddlie, C. (Eds.). (2003). Handbook of mixed methods in social and behavioral research. Thousand Oaks, CA: Sage.

Taylor, B. M., & Pearson, P. D. (Eds.). (2002). *Teaching reading: Effective schools, accomplished teachers*. Mahwah, NJ: Lawrence Erlbaum.

Toma, J. D. (2006). Approaching rigor in applied qualitative research. In C. F. Conrad & R. C. Serlin (Eds.), *The Sage handbook for research in education: Engaging ideas and enriching inquiry* (pp. 405-423). Thousand Oaks, CA: Sage.

Vaughn, M. (2010). *Two teachers' thoughtful adaptations during planning and instruction and the relationship to student agency & teacher visioning. ProQuest Dissertations and Theses.* Retrieved from http://search.proquest.com/docview/847004573?accountid=14604.

Vogt, F., & Rogalla, M. (2009). Developing adaptive teaching competency through coaching. *Teaching and Teacher Education,* 25.

Westerman, D. A. (1991). Expert and novice teachers'decision making. *Journal of Teacher Education, 42,* 292-305.

Williams, T. L., & Baumann, J. F. (2008). Contemporary research on effective elementary literacy teachers. In Y. Kim, V. J. Risko, D. L. Compton, D. K. Dickinson, M. K. Hundley, R. T. Jimenez, K. M. Leander, & D. W. Rowe (Eds.), *57th Yearbook of the National Reading Conference* (pp. 357-372). Oak Creek, WI: National Reading Conference.

Windschitl, M. (2003). Inquiry projects in science teacher education: What can investigative experiences reveal about teacher thinking and eventual classroom practice? *Science Education, 87,* 112-143.

Yin, R. K. (2003). *Case study research: Design and methods* (3rd ed.). Thousand Oaks, CA: Sage.

Yin, R. K. (2009). *Case study research: Design and methods* (4th ed.). Los Angeles, CA: Sage.

Zembylas, M. (2003). Caring for teacher emotion: Reflections on teacher self-development. *Studies in Philosophy and Education, 22,* 103-125.

Zohar, A. (2006). The nature and development of teachers' metastrategic knowledge in the context of teaching higher order thinking. *Journal of the Learning Sciences, 15*(3), 331-337.

APPENDIX A

PRE-STUDY INTERVIEW PROTOCOL

Introduction: Thoughtfully adaptive teaching is the way teachers change their teaching to meet students' needs. We are doing a study to try and learn about how to help students learn more. We are asking you to help because we want to find out what students think about classroom lessons and materials.

Instructional practices:

1. How do you normally teach science?
2. What kinds of materials do you use to teach science?
3. What kinds of methods do you use to teach science?

Visioning:

1. Why did you become a teacher? What is it that you really want to accomplish?
2. What are the big goals you are trying to accomplish as a teacher?
3. What do you want your students to learn?
4. What do you want them to become?
5. How do you attempt to enact your vision? Give me an example.
6. Can you give me an example of a lesson you taught in the past that was designed to enact your vision? What methods did you use to accomplish this?
7. What do you look for in students that indicate they are "getting" your vision?
8. Is there ever a time when you intentionally decide NOT to enact your vision? When? Why?

Context:

9. What would be helpful for us to understand about your teaching context?

10. Can you tell me about your class?

11. What part of your vision are you able/unable to enact at this time?

12. Are there obstacles in your school environment that make it difficult for you to teach the way you'd prefer to teach? What are they? What is the way you want to teach?

13. How do you deal with such obstacles?

14. Does your school have rules you must follow when teaching science? Examples? What do you do?

15. Are you able to do what you want to do in your classroom/school?

Student Outcomes:

16. What do you want your students to know and be able to do as a result of you teaching this science unit?

APPENDIX B

PRE-LESSON INTERVIEW PROTOCOL

Introduction: To help me understand what I will be observing in your lesson tomorrow, I need to ask a few questions about what you will be teaching.

1. What are you planning to teach today?
   a. What is it you want students to be able to do and know?
   b. What instructional strategy are you using?
   c. Why is it important to do today's lesson?
2. Is what you're doing today in any way a change in terms of:
   a. a modification of district or school requirements?
   b. a modification in what the materials suggested to do?
   c. how you have done this kind of lesson in the past?
   d. your instructional strategies?
3. If so, why did you make this change?

APPENDIX C

TEACHER OBSERVATION PROTOCOL

Teacher: Lesson Number:

Date:

In the space below record notes about what the teacher does while teaching and note any instances that appear to be a change from what was planned for teaching.

APPENDIX D

POST-LESSON INTERVIEW PROTOCOL

1. When I saw you do _______ during the lesson. Was that an adaptation?

If yes, why did you make that adaptation?

3. If the teacher seemed to omit something she had planned to do ask: I thought you said during planning that you would do __________ but I didn't see you do it. Why not?

4. Were there adaptations made during this lesson that we have not discussed? If so, what were they? Why did you do that? Repeat questions 2 and 3.

5. Is there anything else you would like to share with me about this lesson, your adaptations or vision?

APPENDIX E

FULL OPTION SCIENCE SYSTEM "MAGNETISM AND ELECTRICITY" UNIT PRE- AND POSTTEST

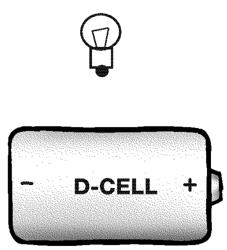
MAGNETISM AND ELECTRICITY
Survey/Posttest

Name	
Date	

1. Wait for your teacher before you begin. Your teacher will tell you how to complete this item.

Object	a. Sticks to magnets?	b. Conducts electricity?
Iron nail		
Plastic straw		
Steel wire screen		
Wooden craft stick		
Brass ring		

2. Draw wires to show how you would light the bulb.

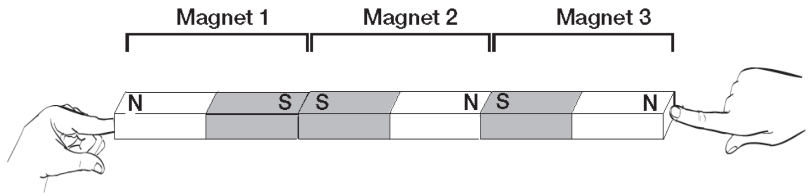


© The Regents of the University of California
Can be duplicated for classroom or workshop use.

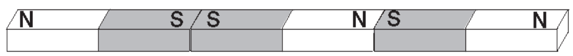
MAGNETISM AND ELECTRICITY

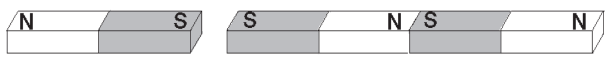
Name

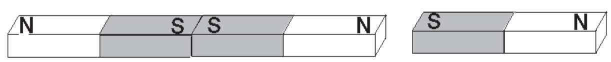
Survey/Posttest

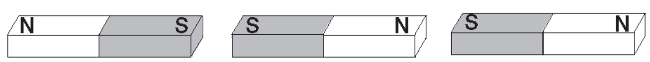


3. Three bar magnets are held together as you see above. What are the magnets going to look like when they are released?

A. 

B. 

C. 

D. 

4. Wendy is making an electromagnet. She wrapped a long, insulated wire around an iron nail. What should Wendy do next to complete the electromagnet?

____

____

____

© The Regents of the University of California
Can be duplicated for classroom or workshop use.

MAGNETISM AND ELECTRICITY

Name

Survey/Posttest

5. Arthur was playing with magnets. He had one magnet on the table, and one in his hand. As he moved the magnet in his hand closer to the one on the table, the magnets suddenly snapped together.

   Explain to Arthur why the magnets snapped together.

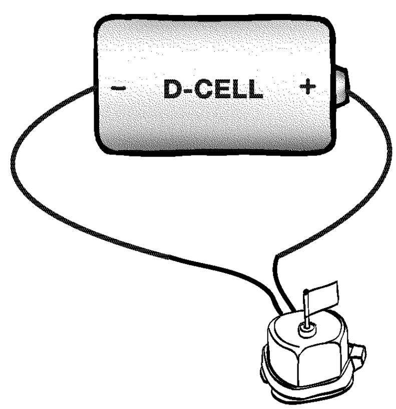
   ____

   ____

   ____

   ____

6. Draw arrows on the picture to show which direction electricity flows through the circuit to run the motor.



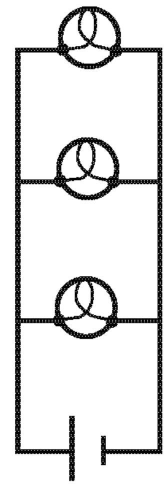
© The Regents of the University of California
Can be duplicated for classroom or workshop use.

MAGNETISM AND ELECTRICITY

Name

Survey/Posttest

7. Look at the schematic diagram.



- What will happen to the other two bulbs if the middle bulb burns out?

- Why does that happen?

8. Annie was making an electromagnet. She had three rivets that she could use to wrap wire around. One was copper, one was iron, and one was steel. Which rivet or rivets should she use and why?

© The Regents of the University of California
Can be duplicated for classroom or workshop use.

MAGNETISM AND ELECTRICITY

Name

Survey/Posttest

9. Imagine you have a box of the following materials: a large iron nail, several permanent magnets, lots of insulated wire, a D-cell, and a switch.

   a. Describe one way to make the nail a temporary magnet.

   b. Describe another way to make the nail a temporary magnet.

10. Samuel Morse, the inventor of the telegraph, had a problem. His telegraph's signal was too weak. He needed a stronger electromagnet. What is one way that he might have increased the strength of the electromagnet for his telegraph?

© The Regents of the University of California
Can be duplicated for classroom or workshop use.

MAGNETISM AND ELECTRICITY

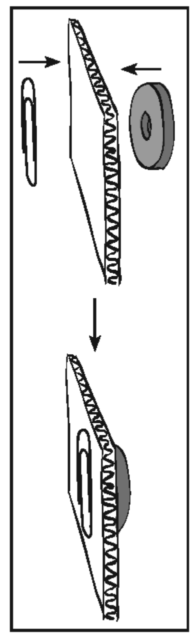
Name

Survey/Posttest

11. Electricity can be changed into other forms of energy.

- The bulb in a lamp changes electric energy into ____________________.
- A motor changes electric energy into ____________________.

12. Julie placed a paper clip, piece of cardboard, and magnet together like you see in the pictures.



Why did the paper clip stay against the cardboard rather than fall to the floor?

____

____

____

____

____

© The Regents of the University of California
Can be duplicated for classroom or workshop use.

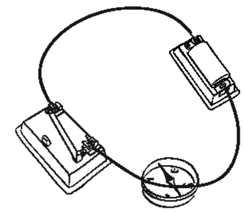
MAGNETISM AND ELECTRICITY

Name

Survey/Posttest

13. A student set up the circuit you see in the picture. There was a compass sitting on the table next to the circuit. When the student connected the plastic-coated copper wire to the battery, the compass needle moved.

    Why did the compass needle move?



(Circle the one best answer.)

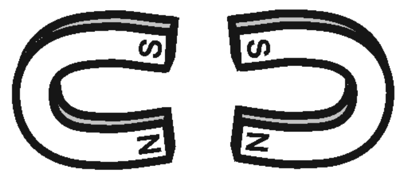
A. Electricity was flowing through the wire to the compass.

B. Magnetic force was flowing from the battery to the compass.

C. The energy flowing through the wire caused the compass to vibrate.

D. Magnetism was created when electricity flowed through the wire.

14. A student placed two horseshoe magnets near each other on a table. What will happen when she lets go of the two magnets?



(Circle the one best answer.)

A. One side of the magnet will repel and the other side will attract.

B. The two magnets will repel and push apart.

C. The two magnets will attract and stick together.

D. The force will be cancelled between the magnets.

15. When black sand and iron filings are mixed together, they look like a black powder. Which of the following would be the easiest way to separate the sand and the filings?

(Circle the one best answer.)

A. Use a magnifying glass.

B. Add water to the mixture.

C. Use a magnet.

D. Use a hot plate to heat the mixture.

© The Regents of the University of California
Can be duplicated for classroom or workshop use.

APPENDIX F

FULL OPTION SCIENCE SYSTEM "MAGNETISM AND ELECTRICITY" UNIT PRE- AND POSTTEST SCORING GUIDE

SURVEY/POSTTEST ANSWER SHEET—1 OF 7

MAGNETISM AND ELECTRICITY

ANSWERS

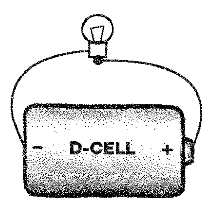
Survey/Posttest

1. Wait for your teacher before you begin. Your teacher will tell you how to complete this item.

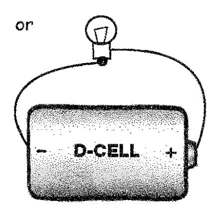
Object	a. Sticks to magnets?	b. Conducts electricity?
Iron nail	Y	Y
Plastic straw	N	N
Steel wire screen	Y	Y
Wooden craft stick	N	N
Brass ring	N	Y

NOTE: *The materials used in this item are provided in the kit. Tell students you will hold up each item for them to see. They should then answer the questions with Y (for yes) or N (for no). Be sure that every student has the opportunity to see each item.*

2. Draw wires to show how you would light the bulb.



or



FOSS Magnetism and Electricity Module
© The Regents of the University of California
Can be duplicated for classroom or workshop use.

SURVEY/POSTTEST CODING GUIDES—1 OF 7

1a

Code	If the student...
3	indicates use of the rule "only iron sticks to magnets" (iron nail and steel wire screen).
2	indicates use of the rule "all metals stick" (marks same objects as in 1b).
1	indicates no apparent rule.
0	makes no attempt.

1b

Code	If the student...
3	indicates use of the rule "all metals conduct" (iron nail, wire screen, and brass ring).
2	confuses "what sticks to magnets" rule with what conducts electricity rule (marks same objects as in 1a).
1	provides any other answer.
0	makes no attempt.

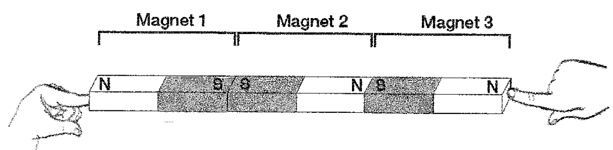
2

Code	If the student...
3	draws a complete pathway with correct contact points.
2	draws a pathway, but the contact points on the bulb and/or battery are incorrect.
1	provides any other answer.
0	makes no attempt.

MAGNETISM AND ELECTRICITY

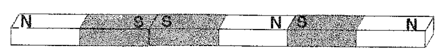
ANSWERS

Survey/Posttest

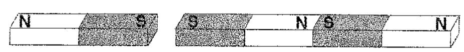


3. Three bar magnets are held together as you see above. What are the magnets going to look like when they are released?

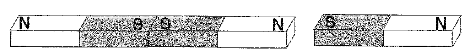
A.



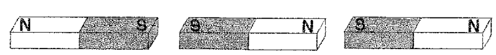
B.



C.



D.



4. Wendy is making an electromagnet. She wrapped a long, insulated wire around an iron nail. What should Wendy do next to complete the electromagnet?

Wendy should hook one end of the wire to the negative side of a D-cell, and the other end of the wire to the positive side of the D-cell.

[Students may suggest including a switch.]

FOSS Magnetism and Electricity Module
© The Regents of the University of California
Can be duplicated for classroom or workshop use.

SURVEY/POSTTEST CODING GUIDES—2 OF 7

3

Code	If the student...
2	circles B.
1	circles A, C, D, or more than one answer.
0	makes no attempt.

4

Code	If the student...
3	indicates that one end of the long wire needs to be attached to one end of the D-cell and the other end of the wire to the other end of the D-cell.
2	indicates that a D-cell needs to be added but gives no other information.
1	provides any other answer.
0	makes no attempt.

MAGNETISM AND ELECTRICITY

ANSWERS

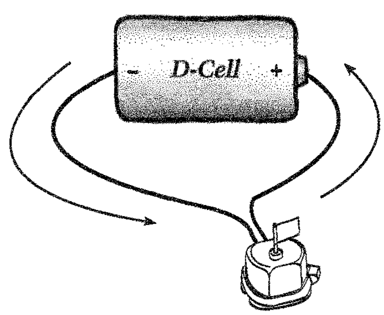
Survey/Posttest

5. Arthur was playing with magnets. He had one magnet on the table, and one in his hand. As he moved the magnet in his hand closer to the one on the table, the magnets suddenly snapped together.

   Explain to Arthur why the magnets snapped together.

   The magnets don't have to touch to attract. When magnets are close together, the force of magnetism pulls them together.

6. Draw arrows on the picture to show which direction electricity flows through the circuit to run the motor.



FOSS Magnetism and Electricity Module
© The Regents of the University of California
Can be duplicated for classroom or workshop use.

SURVEY/POSTTEST CODING GUIDES—3 OF 7

5

Code	If the student...
3	indicates that this happens because the magnetic force works at a distance, so magnets do not have to touch to interact.
There is no level 2 for this item.	
1	provides any other answer.
0	makes no attempt.

6

Code	If the student...
2	indicates flow of electricity goes from negative to positive.
1	draws anything else.
0	makes no attempt.

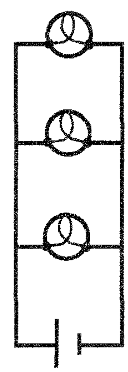
SURVEY/POSTTEST ANSWER SHEET—4 OF 7

MAGNETISM AND ELECTRICITY

Survey/Posttest

ANSWERS

7. Look at the schematic diagram.



- What will happen to the other two bulbs if the middle bulb burns out?

  They will stay lit.

- Why does that happen?

  Each bulb has its own pathway to the D-cell. The bulbs are in a parallel circuit. Bulbs that didn't burn out will continue to shine.

8. Annie was making an electromagnet. She had three rivets that she could use to wrap wire around. One was copper, one was iron, and one was steel. Which rivet or rivets should she use and why?

   Annie should use either the iron rivet or the steel rivet to make the electromagnet. Both iron and steel can be made into temporary magnets.

FOSS Magnetism and Electricity Module
© The Regents of the University of California
Can be duplicated for classroom or workshop use.

SURVEY/POSTTEST CODING GUIDES—4 OF 7

7

Code	If the student...
3	indicates that the other two bulbs will remain lit because each bulb has its own pathway to the energy source.
2	indicates that the other two bulbs remain lit because it is a parallel circuit or because the bulbs still get electricity.
1	provides any other answer.
0	makes no attempt.

8

Code	If the student...
4	indicates that both the iron rivet and the steel rivet can be used for the core because both iron and steel can become temporary magnets.
3	indicates that either the iron rivet or the steel rivet can be used for the core; does not state that this is because these metals can become temporary magnets.
2	indicates that any (or all) of the rivets may be used because they are all made of metal.
1	provides any other answer.
0	makes no attempt.

MAGNETISM AND ELECTRICITY

ANSWERS

Survey/Posttest

9. Imagine you have a box of the following materials: a large iron nail, several permanent magnets, lots of insulated wire, a D-cell, and a switch.

   a. Describe one way to make the nail a temporary magnet.

   Touch or rub the nail with a permanent magnet.

   b. Describe another way to make the nail a temporary magnet.

   Make an electromagnet. Wind the wire around the nail and attach the ends of the wire to the negative and positive terminals of the D-cell. [Students may include a switch in their circuit.]

10. Samuel Morse, the inventor of the telegraph, had a problem. His telegraph's signal was too weak. He needed a stronger electromagnet. What is one way that he might have increased the strength of the electromagnet for his telegraph?

    He could use more winds of wire on the core. **or**

    He could use more or bigger (stronger) batteries.

FOSS Magnetism and Electricity Module
© The Regents of the University of California
Can be duplicated for classroom or workshop use.

SURVEY/POSTTEST CODING GUIDES—5 OF 7

9a

Code	If the student...
3	indicates that a temporary magnet can be made by touching or rubbing the nail with a permanent magnet.
There is no level 2 for this item.	
1	provides any other answer.
0	makes no attempt.

9b

Code	If the student...
3	describes how to make an electromagnet.
2	implies construction of an electromagnet but gives incomplete explanation (e.g. only makes a list of materials).
1	provides any other answer.
0	makes no attempt.

10

Code	If the student...
2	describes one way to make an electromagnet stronger.
1	provides any other answer.
0	makes no attempt.

NOTE: *Students may provide these answers in either order, but codes should be recorded as described here. The code for using a permanent magnet should be recorded as 9a and the code for building an electromagnet should be recorded as 9b.*

SURVEY/POSTTEST ANSWER SHEET—6 OF 7

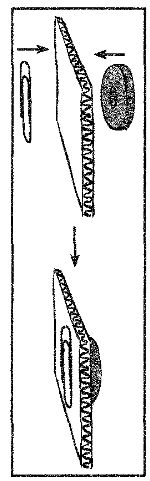
MAGNETISM AND ELECTRICITY
Survey/Posttest

ANSWERS

11. Electricity can be changed into other forms of energy.

- The bulb in a lamp changes electric energy into light.
- A motor changes electric energy into motion (or sound).

12. Julie placed a paper clip, piece of cardboard, and magnet together like you see in the pictures.



Why did the paper clip stay against the cardboard rather than fall to the floor?

The magnetism goes through the cardboard to make the paper clip stay in place.

© The Regents of the University of California
Can be duplicated for classroom or workshop use.

SURVEY/POSTTEST CODING GUIDES—6 OF 7

11

Code	If the student...
3	writes that the bulb converts electric energy into light and the motor converts electric energy into motion or sound (movement, spinning, buzzing, etc.).
2	writes that the bulb converts electric energy into light, but that the motor converts electric energy into something other than motion or sound.
1	provides any other answer.
0	makes no attempt.

12

Code	If the student...
3	indicates that the magnetism goes through the cardboard, holding the paper clip in place.
2	indicates that the paper clip is attracted to the magnet because the paper clip is made of iron or steel.
1	provides any other answer.
0	makes no attempt.

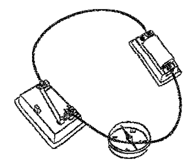
MAGNETISM AND ELECTRICITY

Survey/Posttest

ANSWERS

13. A student set up the circuit you see in the picture. There was a compass sitting on the table next to the circuit. When the student connected the plastic-coated copper wire to the battery, the compass needle moved.

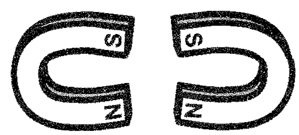
    Why did the compass needle move?



    (Circle the one best answer.)

    A. Electricity was flowing through the wire to the compass.
    B. Magnetic force was flowing from the battery to the compass.
    C. The energy flowing through the wire caused the compass to vibrate.
    D. Magnetism was created when electricity flowed through the wire.

14. A student placed two horseshoe magnets near each other on a table. What will happen when she lets go of the two magnets?



    (Circle the one best answer.)

    A. One side of the magnet will repel and the other side will attract.
    B. The two magnets will repel and push apart.
    C. The two magnets will attract and stick together.
    D. The force will be cancelled between the magnets.

15. When black sand and iron filings are mixed together, they look like a black powder. Which of the following would be the easiest way to separate the sand and the filings?

    (Circle the one best answer.)

    A. Use a magnifying glass.
    B. Add water to the mixture.
    C. Use a magnet.
    D. Use a hot plate to heat the mixture.

© The Regents of the University of California
Can be duplicated for classroom or workshop use.

FOSS

SURVEY/POSTTEST CODING GUIDES—7 OF 7

13

Code	If the student...
2	circles D.
1	circles A, B, C, or more than one answer.
0	makes no attempt.

14

Code	If the student...
2	circles B.
1	circles A, C, D, or more than one answer.
0	makes no attempt.

15

Code	If the student...
2	circles C.
1	circles A, B, D, or more than one answer.
0	makes no attempt.

APPENDIX G

CONTENT OF LESSON SUMMARIES

Lesson Number	Content of Lesson
1	Teachers began a “KWL” and aimed to understand what students already knew about magnets. Students were given test items along with a magnet and prompted to draw conclusions about what magnets do and do not “stick to.” Teachers wanted students to determine that all the items that stuck to magnets were made of metal.
2	After reviewing and pointing out that all the items (from lesson one) were made of metal and were attracted to the magnet, students explored the classroom for more items that were attracted to magnets. Teachers aimed to have students understand that objects must contain steel or iron to be magnetic.
3	Students viewed a video demonstrating a pencil with donut magnets around it that were attracting and repelling. Then, students are given the same materials and asked to feel what was happening. Teachers aimed to provide students with the academic vocabulary words “attracting” and “repelling.”
4	Students create a temporary magnet out of items that are iron or steel by rubbing a magnet on these items. Teachers aimed to assist students with understanding how to make an iron or steel object into a temporary magnet. They also wanted students to understand that magnetic force can travel through solids.
5	Teachers lead a discussion about the magnetic force and worked with the class to establish standard procedures for a “breaking the force” activity. After the procedures were in place, students worked with their groups and collected data on how many washers it took to break the force of a number of magnets.
6	Students were given the necessary materials to create a circuit to light a bulb. Teachers aimed for students to understand that the wires had to be touching the proper place on the light bulb in order to complete the circuit and light the bulb.
7	Students created a circuit and then tried opening and closing the circuit. Teachers aimed to have students understand that to have a complete circuit, energy had to travel in a circle and that when this happens a receiver will work.
8	After students created a circuit they tested items to determine if the items were conductors or insulators. Teachers aimed for students to understand that metal conducts electricity and non-metals do not.

Lesson Number	Content of Lesson
9	Students rotated through stations to test “Mystery Circuits” and indicated which were closed circuits. This was used as an assessment.
10	After students built a circuit with more than one energy receiver, students were introduced to schematic diagrams. Teachers aimed to have students understand that circuits can have more than one energy receiver.
11	After teachers reviewed series circuits, they introduced parallel circuits and had students create a circuit with two pathways for the flow of electricity.
12	Teachers introduced electromagnets with a video and prompted students to think about how the crane in the video works. Teachers explained how the flow of electricity creates a magnetic field. Students were then given all the necessary items and asked to work with their group to build an electromagnet.
13	Students continued to work on the electromagnet with the task of testing the number of winds it takes to make a stronger electromagnet. Each group of students was assigned a number of winds and had to report the number of items the electromagnet was able to pick up without breaking the force. Teachers aimed for students to understand that for the electromagnet to be stronger, there had to be an increase in electricity.